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ABSTRACT

Presented is a report on the work of Cybernetics Research Institute (CRI) investigators on the development of deaf-blind communication and control systems (DEBLICOM). Described in Part One is one embodiment of DEBLICOM designed and built by CRI engineers. Reported in Part Two are experimental procedures and human factors considerations of component and sub-systems design. A description of a portable instructor's/user's controller is covered in Part Three. Part Four examines work on a speech synthesizer and a detailed manual developed at CRI. The status and the difficulties encountered in obtaining an artificial mechanical hand for use as a sub-system of DEBLICOM are reported in Part Five. It is noted that no failures have occurred in the tests of the prototype solid-state system. Also included are appendixes on instructional procedures for programing acceptable American speech with speech synthesizers, a brief report on phonemes, two articles on aids for children with multiple handicaps, and a work plan on DEBLICOM which describes 22 tasks in four work areas (DEBLICOM harness and code for the deaf-blind, mobility aids for the deaf-blind, synthesized speech for the deaf-blind, and project reports). (Author/SB)

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INTERIM PROGRESS REPORT
ON

DEBLICOM

DEAF-BLIND COMMUNICATION & CONTROL SYSTEMS
GRANT NO. 23-P-57488/3-03
Period Covering August 1974-August 1975

Submitted to

REHABILITATION SERVICES ADMINISTRATION
OFFICE OF HUMAN DEVELOPMENT
DEPARTMENT OF HEALTH, EDUCATION AND WELFARE

By

CYBERNETICS RESEARCH INSTITUTE
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PREFACE

The impetus for this project to develop communications and control aids for persons who are deaf-blind (DEBLICOM), thereby leading to help persons who are severely disabled become more self sufficient and employable, came from members of the Rehabilitation Services Administration, Department of Health, Education and Welfare and investigators at Cybernetics Research Institute (C/R/I), as part of deliberations on the desirable future role of rehabilitation engineering and social programs directed to serve the deaf-blind.

Initially the first questions raised by the investigators at C/R/I concerning this segment of the severely disabled population were:

Would the properties of the remaining senses of a person in whom the major deprivation of both hearing and visual sensory capabilities has taken place be sufficient to establish communication?

What are the prospects of using the remaining senses through the use of state-of-the-art means that are not only feasible technologically, but are acceptable politically, socially, legally and economically?

Information regarding the first question is well known by the achievements and skills acquired by Helen Keller. She was one of the first deaf-blind persons to direct the world's attention to her extraordinary ability to acquire language with comprehension. The accomplishments of her teacher, Anne Sullivan, stand as a landmark in the hall of rehabilitation fame. But today the problems are more than the involvement and resources

necessary for the training of deaf-blind persons and instructors. As for the technological question, judgement at this time cannot be made in the middle of the various developments of systems that are yet to be evaluated and tested. Nevertheless, it can be stated that the results of this project have already produced valuable information which clearly warrants extending the basic concept proposed, i.e., the use of coded information in a tactile man-machine system as described in this report.

There is another aspect that is of concern. In the past where changes have been imposed, especially in a classroom or rehabilitation environment over which instructors, teachers, or therapists believed thay had little control, there was a real sense of inadequacy in their feelings of competence. Rather than accept the risk of blatant failure by adopting new ideas, workers in the field found it less menacing to simply refuse to adopt or use innovative systems of which they knew little. But today the situation has changed considerably. Today's rehabilitation and social workers, counsellors, and special educators who serve disabled persons are equipped to comprehend innovative systems. They have literally grown-up in the age of electronic wizardry and computer sciences, space travel, and almost unbelievable health and medical care systems. They are prepared to accept technology; for not only are their daily lives surrounded by actual testimony of scientific and technological achievements, but they are frequently innovators themselves. Constraints imposed

upon them are in other areas, such as their need for better facilities, their concern about operating budgets (which are limited) and the additional administrative reponsibilities imposed upon them which reduce their effectiveness. But as astute as they are, today's counsellors, teachers, therapists, and others in the field are aware of the shortcomings of existing methodologies which originated out of observations of persons who were not multiply handicapped, e.g. the use of antiquated "developmental scales". With dependency on methods such as this, it is no wonder that the results of their evaluations with multiply impaired persons are questionable and show little if any predictive validity.

Hence, there is a strong reason to support their needs for innovative cybernetic technology, a technology that will help those in whom society has placed their trust, to educate, habilitate and rehabilitate persons who are severely disabled.

It is our hope that these endeavors contribute to those rehabilitation efforts directed to assist persons who are deaf-blind in order that they may "come out of the prison of silence" (Helen Keller, 1902) and that these reflections cast a shadow of the flight of the bulbul and shed an echo of her song.

Haig Kafafian
Principal Investigator
August 31, 1975

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To be engaged in an innovative research program involving a wide range of disciplines calls upon the technical and human resources of many people. Ours is the good fortune to have received cooperation from many who have responded with alacrity toward advancing the objectives set forth to provide assistive aids for persons who are deaf-blind. Although the names of all of these individuals do not appear here, the investigators acknowlege their contributions.

In addition, the principal investigator is indebted to the following members of Cybernetics Research Institute (C/R/I): Maricha Brent, James Gouge, Richard Hopkins, Rose Kafafian, Walter Keith, Sheridan Speeth, John Williams, Anna Coates, Daniel McCarthy, Robert Murphy and Darryl Urcheck. Special appreciation is expressed to Earl Brawner of the Library of Congress for his cooperation.

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Part One

INTRODUCTION

This report covers work performed by C/R/I investigators from August 1974 through August 1975 on the development of an innovative communications and control system directed to serve that segment of the severely disabled population who are deaf-blind and/or may be unable to speak intelligibly. The project is supported in the major part by the Rehabilitation Services Administration, Office of Human Development, U.S.Department of Health, Education and Welfare and in part by Cybernetics Research Institute and Cyber Corp.

The investigators are pleased to report on the progress in the development of a two-way communication and control system for use by persons who are deaf-blind (DEBLICOM) which employs systematic coding of information (Kafafian,1968) with standard keyboards and a family of interfaces for persons who do not have finger dexterity or limbs(Kafafian,1973). Features of the system are described in this report along with results of preliminary testing of a prototype artificial speech system.

Part One of the report describes one embodiment of DEBLICOM with illustrations of the equipment designed and built by C/R/I engineers. Part Two describes experimental procedures and human factors considerations of component and sub-systems design. Illustrations and description of a portable instructors/user's controller is covered in Part Three. Part Four describes work on a speech synthesizer and a detailed manual developed at C/R/I which appears in Appendix A. To date no failures have occured in the tests of the prototype solid-state system. C/R/I has employed

the low-cost features of commercially available devices. Part Five reports on the status and the difficulties encountered in obtaining an artificial mechanical hand at this time for use as a sub-system of DEBLICOM.

Part Six includes the references examined for pschophysics and human engineering data useful in optimizing available output devices for the tactile palpable vibrators and their locations on the harnesses.

Although the budget for this project was reduced from the initial work plan, the basic design has not been sacrificed and options for inputs such as, the collision avoidance, identification and control system (Kafafian,1975) can be incorporated later.

The appendices include the phonetics manual mentioned earlier. This was used to program a set of Read-Only-Memories (ROMs) to permit complete words and phrases to be generated whenever a single control function signal comes from the deaf-blind and/or speech-impaired person. C/R/I investigators are continuing the ROM programming of ROMs; the phrases to be added are those which are most often suggested from the C/R/I field studies.

The techniques employed by C/R/I in formulating its design for presenting information to and getting information from persons who are deaf-blind were based on a careful consideration of human engineering and learning theory. Studies of stimulus factors were used to obtain an input system which would maximize effective information processing.

A one-to-one mapping between the coded stimuli-presented and the form of unambiguous response code ensures maximum transfer to training from input recognition to output production.

The work of C/R/I during this period revealed the importance of the technique employed in coding information when designing a two-way communication system for use with the deaf-blind. As Reynolds has stated:

"The coding of information for communicative purposes is a predominantly human accomplishment whereby objects, events, or ideas are represented by stimuli which do not share physical properties with their referents. Familiar examples of stimuli coded to convey meaning to human observers are phonemic speech and graphemic writing, Morse Code, the manual sign language of the hearing-impaired, and braille. Since coded stimuli seldom simulate the characteristics of their referents, stimulus items and assigned meanings must be learned through association to be useful in communicating.

The development of a communications code should take into consideration human perceptual, motor and cognitive characteristics to enhance efficient message transmission and reception. The sensory pickup of coded information is critical not only on the reception of a message, but also in its transmission. For example, the act of speaking requires auditory feedback of speech sounds and tactile-kinesthetic feedback from the vocal musculature to assure intelligible continuity and enunciation of speech. Similarly, the act of signing by the hearing-impaired requires visual and kinesthetic feedback to provide the signing individual with information about the positions of his hands and fingers. This information feedback, essential for the transmission of a message, is itself coded to specific meanings or referents.

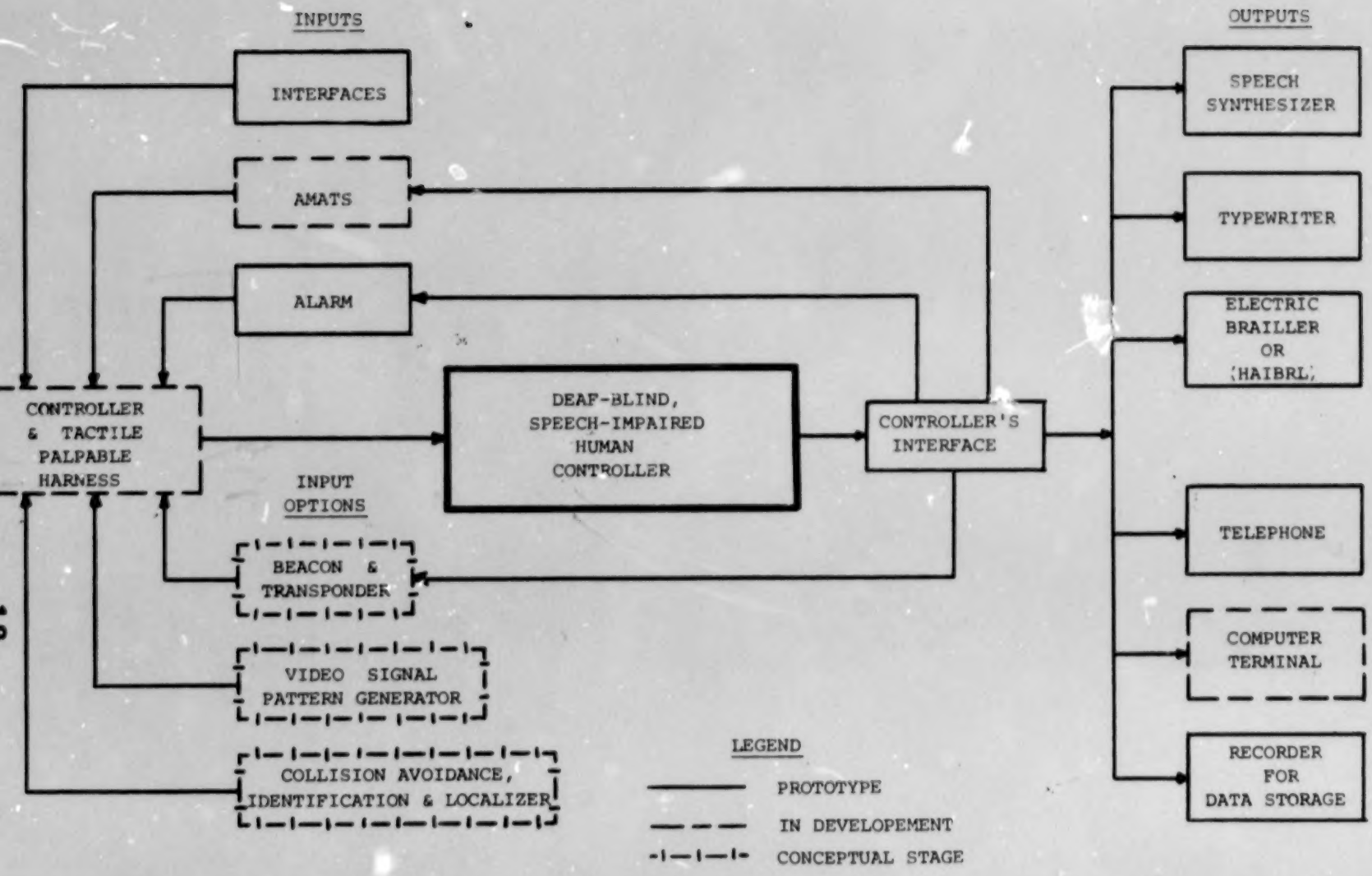

FIGURE I. Block Diagram of the DEBLICOM communications and control system.

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Consequently, for an individual to both transmit and receive a message, at least two different kinds of coded sensory information must be differentiated and comprehended. In the case of message reception, coded stimulus information is picked up by the perceptual systems and associated with assigned meanings or referents. The transmission of a message requires that meanings or referents be associated with specific bodily movements or acts which are controlled through sensory feedback"*.

Effective speech requires tactile,kinesthetic and auditory feedback; signing requires kinesthetic and visual feedback. Without the ability to use sight and hearing, the best we can do is provide assistive aids which supply information through the remaining senses, It is toward this end that the DEBLICOM systems are directed, using coded information applied to and received through the use of the deaf-blind persons tactile and kinesthetic systems.

To use the code for conversing with sighted individuals the staff at C/R/I have built a portable logic and display system which serves several purposes; one for instructors, one for the deaf-blind subject and one for collection of data. Part of the system is shown in Figure II,along with a 16-key dual-input interface with which the teacher or the deaf-blind student can simultaneously run both the display and the stimulus harness which is worn by the student. The 8 left keys control the vibrators on the student's

* Reynolds, H., (1970), "Coding of Sensory Information in Communication Systems for the Handicapped". A paper on work performed at C/R/I presented to the symposium in "Coding of Sensory Information for Artificial Human Communication Systems", Annual Meeting of the American Psychological Association.

left side and the 8 right keys the vibrators on the right. For the sighted teacher a light emitting diode illuminates a message on the display board. Its row corresponds to the left hand key input an its column to the one from the right.

Figure III.shows alternative inputs for controlling the display and harness when the subject has motor difficulties.

Figure IV. shows the unit with its circuits exposed. and Figure V. has a close-up of one of its logic boards.

The deaf-blind need more than a means of communicating with others. We are presently investigating means to modify such mobility aids as the sonic glasses and optical cane (Nye and Bliss, 1970) to make them drive C/R/I's DEBLICOM harness. In these instances the audible output is replaced by tactile outputs. This would permit their use by persons who are deaf-blind as well as persons who are blind, but have no hearing problem.

The report concludes with a set of references of value to those working in this field. It includes alternative approaches to ours, experiments with tactile stimulation, observations on the deaf-blind, traditional training methods used with the deaf-blind, and other related materials. The staff of C/R/I looks forward to the forthcoming period in which it will continue its work in this critical area

It has been a continuous aim of C/R/I to ensure that the results of this work be available to as many potential users as possible and that only a small delay exist between the development stage and utilization in actual rehabilitation situations. The letter in Appendix B shows one of the several seminars which have beeen arranged by C/R/I to convey the findings to others. Many

of C/R/I's results can already be applied to ongoing rehabilitation programs. C/R/I's work on the synthesis of speech and on telephone controlled braille equipment (See Figure VII) serves as two examples.

> *"Human-engineered interfaces have been designed to couple the remaining motor control of handicapped individuals so that there is a quantitative compensation for specific physical disabilities and/or neurological dysfunctions. Persons who heretofore were unable to produce cursive writing or use typewriter keyboards, computers, and telephones are now dramatically demonstrating their ability to communicate. Deaf, deaf-blind, and language impaired individuals may now learn to communicate with each other and control automata, via appropriately coupled interfaces and programming methods."*
>
> - Kafafian. Excerpt from a paper "Cybernetics Systems in the Education of the Handicapped," for the American Society for Cybernetics, Fourth Annual International Symposium, Washington,D.C., October 8-9, 1970. (Other boxed quotations which follow, unless otherwise noted,are from the same paper.)

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EXPERIMENTAL PROCEDURES
&
HUMAN ENGINEERING CONSIDERATIONS IN THE DESIGN OF THE DEBLICOM STIMULUS HARNESS

Part Two

One of the goals of the DEBLICOM (Communications and Control System for Deaf-Blind, Speech-Impaired Persons) project is to establish a means of communication with persons who are deaf-blind. A harness of palpable vibrators worn by the user will provide two simultaneous input signals through a unique, dual-input code (Kafafian, 1968, 1973). Initially, in the tests, sixteen transducers will be used, eight on the left side of the body and eight on the right side. In one embodiment, each code member will be assigned two vibrators, one on each side. There are sixty-four dual-input combinations or code combinations. (This is in the simplest or "single-state" mode of operation). In the following we will discuss the human engineering considerations which led to the design and refer to relevant experiments.

Patterns of two stimulus positions were employed because such patterns are more easily discriminated than either the position of one stimulus position (at any one of the palpable vibrators) or patterns of three or more stimulus positions (Geldard and Sherrick, 1965).

The DEBLICOM harness will have its transducers arranged so that the vibrators will be separated from one another as far as practical (Bliss et al., 1970).

Vibration levels (displacement) will be between 50 and 400 microns. A level of 50 microns is well above the threshold for feeling and a vibration of 400 microns is safely beneath the threshold for pain (Geldard, 1957, 1960).

Palpable vibrators rather than electrical stimuli will be used because of variability in the skin resistance over time and between loci. It is difficult to get much range between threshold for feeling and threshold for pain (Gilson,1963). We are not ruling it out, however, since it may be feasible to get around the electrical problem with a constant current source, and the pain problem by using concentric circular electrodes to produce a gradient (Sherrick,1974). Other modes of stimulation (i.e., thermal and so on) and combinations thereof are being explored.

The first phase of this study has yielded the following considerations for exploration as applied to a useful and practical communications system:

The skin's sensitivity to vibratory stimuli increases markedly with increasing vibration rate until it reaches the range of maximum sensitivity which lies between 150Hz and 500Hz and declines above that (IEEE, 1970). Vibration rates in this range have been selected for design of the palpable vibrators and their source of excitation.

Two approaches to vibration generation are being considered. One is through the use of a solenoid much as is used in magnetic speakers and earphones (Sherrick, 1965). Although this approach is not efficient as frequency increases it may be that this will be offset by other factors. The other approach is to use bimorphs which are piezoelectric. They are efficient and have mechanical resonance in the 200Hz region which is in the range of maximum skin sensitivity (Rogers, 1970). In the design we plan to test, each vibrator will be surrounded by a non-vibrating region to suppress the spread of the skin's mechanical vibration.

Such surrounds have been shown to produce lower, less variable thresholds, and better localization (Verillo,1962; Gilson,1968).

An experiment will be conducted to establish the performance level of subjects in the dual-input code using position alone. Both rate of acquisition and final message and error rate will be measured.

An experiment will then be conducted to test the extent to which adding other dimensions to stimulation can add to the discriminability of the code members. The knowledge that stimuli are more easily discriminated when they differ along more than one stimulus dimension (Miller,1951;Pollack and Ficks,1954) will be considered in this design.

In reviewing the literature on the discrimination of tactile stimuli C/R/I investigators have selected the following pertinent points:

a) Absolute judgements of intensity can be made reliably with,at most, three categories of intensity. (Howell,1956).

b) Only three stimulus durations between 0.1 and 1.0 seconds can be recognized accurately (i.e., without comparative referent) (Geldard,1957,1960).

c) Only two levels of attack rate can be separated with complete accuracy in the attack slope range between 0.0 and 0.6 second (Howell,1958).

To supplement the positions code with redundant information the following procedure has been derived:

a) Each group of eight code members sharing one right side stimulus position shall be divided into two groups of four by assigning the first four one intensity and the other four another.

b) Each group of four code members sharing the same stimulus position on the right side and the same intensity level will be divided into two groups of two assigning two of them one duration of stimulation and the other two another.

c) Each group of two code members sharing the same right side position, the same intensity, and the same duration shall be divided in two by assigning one attack rate to the first and another to the second.

Thus any two members of the code will differ clearly from one another by at least one of two of their stimulus positions and by at least one of three of their other stimulus parameters. The additional redundancy should enhance performance. The dimensions to be employed could also be used to increase the code size with a loss of redundancy.

Additional redundancy could be added by using apparent movement due to relative intensity (IEEE,1970), Bekesy's pulse timing effect (IEEE,1970), the tactile phi-effect (Geldard,1957), or the so-called "Rabbit effect" (Geldard and Sherrick,1972). Thus half of the stimuli could appear to move from right to left and the other from left to right.

During the forthcoming phase, investigations in the frequency coding, and modulating of the intensity of the pulse with low frequency signal (vibrato) will be made. The former was not used initially because of the strong dependance of tactile "pitch" on intensity (Bekesy,1957,1959). Modulation has not, to our knowledge, been investigated.

Three more stimulus parameters would give us yet another level of redundant dimensions.

The advantages, if any, of a redundant code will be assessed by teaching both the redundant and the non-redundant codes to normal subjects in our laboratory. Both acquisition rate and final performance level will be measured.

The final dual-input code decided upon will then be taught to selected deaf-blind subjects. The principles of response differentation and discriminative stimulus control will be employed (Skinner, 1938; Keller, 1969). This will consist of first finding stimuli which are reinforcers for the subject (i.e., food, candy, a hug, and so on). Then the reinforcement will be made contingent on the occurance of some responses (e.g., reaching for a glass of water). Once the response occurs frequently, reinforcement will be delivered only in the presence of the appropriate code pattern (e.g., the one for water).

After training on the code, the deaf-blind subject will be presented with two sets of eight keys, one for the right hand and one for the left. The keys for the left hand will correspond to the vibrators on the left side of the body and the right hand keys to the right side. The vibrator pattern will have acquired secondary (i.e.,conditioned)reinforcing properties and this should motivate exploration and learning (Keller,1969). In addition, the one-to-one mapping of the dual inputs into the dual vibrator positions should result, through transfer of training, in the rapid acquisition of the key vibrator code (Kafafian, 1970). Thus when the subjects' keyboards are interfaced with a display or recording device, they will have established two-way communication with their environment.

TABLE OF REDUNDANT INFORMATION FOR DUAL-INPUT CODE

POSITION	INTENSITY	DURATION	ATTACK RATE
1	weak	short	rapid
2	intense	long	prolonged
3	weak	short	prolonged
4	intense	long	rapid
5	intense	short	prolonged
6	weak	long	rapid
7	intense	short	rapid
8	weak	long	prolonged

Shown in Figure VIII are the ways in which redundant information will be added to the eight positions on each side of the body using the dual-input coding procedure. It is presented above in tabular form. The values for each of the three dimensions are shown in the diagram as points. It should be noticed that each position differs from its nearest neighbor by at least two dimensions (and for four cases by all three dimensions).

"Consideration of man-machine systems designed to efficiently utilize a person's remaining motor capabilities may provide solutions heretofore not available. Through use of these systems, many disabled persons will overcome their handicaps and become equal to and even exceed standards of performance usually established for nonhandicapped individuals. It is through an understanding of the handicapped person's human requirements, recognition of their remaining motor capabilities and application of the principles of cybernetics, that many of them can, when given the opportunity and appropriate feedback systems, supplement their living systems with surrogates. It is through these insights that researchers engaged in studying systems to enhance man's communicative abilities can offer new hope."

FIGURE VIII. DIMENSIONS OF REDUNDANT CODE

INSTRUCTOR'S TRAINING AID

A compact version of the "WHISPER-TYPE" display and control system was built at C/R/I for use in the program. It serves three purposes as follows: (1) use by instructors who are sighted in their training program to establish two-way communication with the deaf-blind (2) to provide inputs to harness transducers or palpable vibrators on the person who is deaf-blind (3) to provide signals for data collection. The use of light emitting diodes in place of incandescent lamps, and solid-state circuits in place of electro-mechanical stepping switches has made it possible to reduce the controller of this system to the size of 10"x12"x3 ½". It is fully portable and interacts with a DEBLICOM harness in a straightforward manner. The visual display for use by the instructor has been reduced in size from that of the standard unit to 10¾"x 10¾"x 1" and is separate from the controller. Both the reduction in size and the physical separation of the display from the controller increase the utility and portability of the personalized unit (see Figure III).

Its messages may also be recorded with a terminal such as the CYBERPHONE, or a Touch-Tone® telephone for playback at a later time or for communicating over telephone lines to a remote location. The Instructor's Training Aid does not need additional peripheral equipment to permit full two-way communications. The display consists of an 8x8 matrix of LED's which illuminate the 64 coded messages. With the dual-input code, the 8 rows of the display correspond to the 8 left hand keys and the left side vibrators of the DEBLICOM harness; and the 8 columns correspond to the right hand keys and right side. The compact or "personalized" version of the system can be controlled through use of a variety of input interfaces. These include a plate switch, a single-button interface

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and pneumatic, myoelectric or microphone interfaces. It also has the capability of accomodating multiple-key interfaces such as a unilateral 8 key interface or a bilateral 16 key interface. The style of interface selected depends on the capability of the instructor and the person who is deaf-blind.

The system used by the teacher has its own low-power solid-state display and has the capability of driving other communications and control devices.

An "alarm", or "SOS" function has also been included. It has been designed to accept fire alarm or emergency signals. The unit operates on 115V-120V AC, 60 Hertz or it may be powered from rechargeable batteries for mains-free operation.

In addition to serving as an assistive aid for the intructor working with the student who is deaf-blind, the personalized version of the DEBLICOM controller can be used to generate high powered low frequency acoustic signals supplementing the operation of the palpable vibrators (or transducers) on the harness worn by the user. This feature together with the generation of high intensity light (for use by deaf persons who are losing their sight but still have sufficient vision to detect high intensity lights) will be further investigated in the forthcoming period.

"Today, we are applying the principles of feedback-control in order to better understand and hopefully reveal new insights and features of learning which are at times missed or overlooked by reinforcement theory. For example, the spatial organization of purposeful behavior is an aspect that is basic to the theory of feedback-control, but is frequently not clearly conceptualized by reinforcement learning models."

Part Four

SYNTHESIZED SPEECH

FOR THE DEAF-BLIND

The generation of natural speech is extremely difficult for persons who in their early life have become deaf-blind even after they acquire proficiency with the Tadoma method of tactile lip reading (Keller, 1902;Hansen,1964). Recent technology has made it possible to generate highly intelligible artificial or synthesized speech at relatively low cost. Investigators at C/R/I from August, 1974 to August, 1975, have investigated the application of artificial speech generation systems for persons who are deaf-blind and for persons who have severe speech impairments. After considering the available alternatives a system produced by the Vocal Interface Division of the Federal Screw Works Corporation, Troy, Michigan was purchased. The device consists of a set of phoneme generating circuits which control a speech synthesizing network.

An instructional manual for the use of phonetic keyboards (including interfaces for orthopedically and/or neurologically impaired persons) in the production of natural sounding speech was produced during this period. A detailed preliminary version of the manual is included in Appendix A of this report.

The concepts of the manual were used to generate the sounds of the letters of the alphabet and machine control functions together with a test set of commands and messages for use by persons who are deaf-blind. The machine control language phonetic transcriptions were then used to program a set of Read-Only-Memories (ROMs) so that an entire letter or phrase could be called-up with a single control dual-input code.

These transcriptions are presently being expanded so that the ROM programmed functions shall include the requests, phrases, and concepts which would be most valuable or most frequently used by persons who cannot speak. This list of messages is being compiled following the recommendations made by workers at C/R/I's field centers and other rehabilitation organizations. The resulting set of the 64 most important concepts and requests is being programmed to be available as synthesized speech by the deaf-blind using the dual-input coding system with vibratory feedback (described in other sections of this report).

The engineering staff at C/R/I has, during this period, completed the construction of circuitry in a compact form needed for the control of a "WHISPER-TYPE" output and has coupled it to the speech synthesizer. This arrangement also permits the instructor or people with normal hearing to engage in two-way communication with the deaf-blind through the use of a telephone. In one embodiment the person calling would send his message by pushing two consecutive Touch-Tone ® dial numbers corresponding to the left side and right side vibrators to be activated at the receiving end. The logic circuitry which translates the "Touch-Tone" signals into the proper vibrator patterns has been completed in this phase of the program. The system is designed so that a deaf-blind individual can use the phone with synthetic speech. This concept will serve additional functions for the deaf-blind and open future fields of exploration in the rehabilitation of persons who are not only deaf-blind, but for persons who have vision and hearing, but have severe speech impairments.

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Part Five AMATS

AUTOMATED MANUAL ALPHABET TRANSMITTING SYSTEMS (AMATS)

In the C/R/I preliminary progress report it was stated that our investigators had decided not to construct a mechanical hand system at this time. This was to have been used as an aid in the training of the manual alphabet using either pre-recorded program tapes or a manual keyboard. The tapes were to have provided automated instruction in the manual alphabet.

The principal investigator described this concept to the late Hector Kay of the Committee on Prosthetics Research and Development of the National Academy of Sciences. He provided C/R/I with much information on the state-of-the-art of artifical hands and limbs (Yugoslav Committee for Electronics and Automation,1970). On the basis of this, it was decided to postpone this development until the design of an appropriate hand was completed.

Since C/R/I's initial report, we were pleased to hear that a prototype artificial hand has been announced by Charles Laenger and his associates at the Southwest Research Institute (SwRI). Our investigators have been in contact with SwRi and are following their work. If it is found they can provide C/R/I with a working model, it is intended to continue the investigation of its use with persons who are deaf-blind. Since their device is in the feasability and development stage, it is not clear whether or not they may be able to provide C/R/I with a model for testing in the forthcoming period. Consequently subsequent reports will cover the status of this aspect of the project. If a unit is available, there appears no problem in coupling it with the same logical system which now controls the vibrator harness, the"WHISPER-TYPE", and the voice synthesizer

Part Six

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Strengthen ye the weak hands, and make strong the feeble knees.

Say to them that are of a fearful heart, Be strong, fear not...

Then the eyes of the blind shall be opened, and the ears of the deaf unstopped.

Then shall the lame man leap as a gazelle and the tongue of the mute sing...

Isaiah 35: 3-6
circa 725 B.C.

Appendix A

INSTRUCTIONAL PROCEDURES

I. INTRODUCTION

The purpose of this section is to present the elements of phonological theory needed to facilitate the programming of acceptable American speech with speech synthesizers, and to show the application of this theory to the programming of a commercially available synthesizer, the Votrax-6.*® It was prepared at Cybernetics Research Institute (C/R/I)® with the support of the Rehabilitation Services Administration, Office of Human Development, under grant No. 23-P-57488/3-03, covering research to improve communication and control of deaf-blind and severely speech-impaired persons.

A family of assistive communications and control aids for persons who are deaf-blind having cognitive and learning abilities and motivation to communicate and control we have identified as DEBLICOM. It has been adapted for use with "Votrax-6", a commercially available speech synthesizer. One purpose of DEBLICOM is to enable speech-impaired or mute persons to "vocalize" through the use of a phonetic keyboard. Where physical and neurological dysfunctions preclude use of a standard keyboard arrangement, single-key, 8-key, or 16-key CYBERTYPE® interfaces** may be used.

II. EXPANSION OF EXISTING USER'S MANUAL

The currently available user's manual has been expanded in a number of ways, thereby enhancing its utility for the programming of acceptable American speech, especially by persons who are

* ® Vocal Interface Division, of Federal Screw Works, Troy, Michigan
® Cyber Corp., Washington, D.C.
* See Vol. III, Study of Man-Machine Communications Systems for the Handicapped"

severely handicapped with speech impairments or the lack of a speech capability. Specifically, the expansion is designed to:

1. Instruct users in the programming of phrases, clauses and sentences.
2. Teach pitch patterns in words, phrases and sentences.
3. Teach the important features of stress and accent.
4. Teach the feature of internal juncture which is phonetic in English.

Since all of the preceeding must be accounted for and programmed into the machine to give a realistic natural reproduction of English, a supplementary series of new material and instructions have been developed. They provide an improved, more efficient output along with explanations which can assist the programmer/user with the capabilities and constraints of synthesizers.

The following sections are presented as an introduction to programmers/users and new workers in the field. In order to realize the maximum benefit from these instructions it is suggested that the user first review and master the basic phonological theory of English.

As a prerequisite, Part Nine, the phoneme section of the "Study of Man-Machine Communications System for the Handicapped" Vol.III (Kafafian) should be reviewed especially Table XXIV,Chart of Aggregated Consonant Phonemes and Table XXV, Chart of Aggregated Vowels Phonemes. (See Appendix B, this report)

III. PHONEMIC/PHONETIC CORRESPONDENCES

When sounds of English are analyzed and identified, prior

to programming a synthesizer, it becomes rapidly apparent that the English alphabet cannot be used to describe and list them all. This constraint is based on the fact that there are simply too many combinations of letters that symbolize the same sound. An excellent example of this type of ambiguity is the three letters or combinations of letters which can be used to represent the first sound of the word fish. Should it be represented by f as in fill, by ph as in phone, or by gh as in rough? The orthographic system contains too many ambiguities to be used in a precise, scientific description of the sounds of a language. Fortunately, linguists have constructed an artificial system of representation called the International Phonetic Alphabet (IPA) one function of which is to represent sounds (or phonemes) of English through the use of IPA symbols. It will be noticed that many symbols correspond to letters of the alphabet. (At this point before proceeding, the reader should become familiar with Table I which will be the basis for future discussions and practice exercises.)

III.A. THE PHONEME

Phonemes are units of sound which have meaning in a particular language. Symbols for each sound are normally placed between two diagonal lines (//). An example of an English phoneme is /p/, the first sound of the word pill. This phoneme contrasts with the sound /b/ the first sound of the word bill. In the pair of words such as these (called minimal pair, in which only one sound contrast differentiates the two words or phrases), the spelling is different, the number of sounds is the same, yet the meaning is

TABLE I
PHONEMIC-ALPHABETIC CORRESPONDENCES

PHONEME	ALPHABETIC EXAMPLE	PHONEME	ALPHABETIC EXAMPLE
	CONSONANTS		
/b/	bill	/t/	till
/d/	dill	/v/	ville
/f/	fill	/w/	will
/g/	gill	/y/	yet
/h/	hill	/z/	zeal
/l/	lill	/$\overset{v}{\text{ə}}$/	thy
/m/	mill	/$\overset{v}{\text{s}}$/	shall
/n/	nil	/$\overset{v}{\text{z}}$/	rouge
/p/	pill	/$\overset{v}{\text{č}}$/	chill
/r/	rill	/$\overset{v}{\text{j}}$/	jill
/s/	sill	/ŋ/	sing
	VOWELS		
/i/	beat	/o/	boat
/I/	bit	/ɔy/	toy
/e/	bait	/U/	put
/ɛ/	bet	/u/	moon
/ae/	bat	/ə/	but
/a/	hot	/e^{r}/	fur
/ay/	bite	/au/	gouge
/ɔ/	bought	/yu/	use

different. The minimal pair of bill and pill demonstrates more clearly the fact that spelling and sound segments are not perfect mirror images of each other. The sounds /p/ and /b/ are two different phonemes essentially because their appearance in otherwise similar words signals a difference in meaning. There are other reasons why /p/ and /b/ are considered phonemes, but they are not revelant to this discussion.

III.B. ALLOPHONES

Allophones are subclasses of phonemes. Symbols for allophones are normally placed between brackets ([]) to show that they are members of certain classes of sounds, or phonemes. The initial sound of the word pot belongs to the same phoneme class as the second sound of the word spot, but these two p-sounds are not produced in exactly the same manner. In pot, a puff of air (aspiration) accompanies the production of this sound, whereas in the p-sound spot, there is no such aspiration. Linguists can predict when each sound will occur; the aspirated p-sound occurs always in the initial position and optionally in the final position of a word; the non-aspirated p-sound always occurs after the sound /s/. A native speaker of English hears and produces these two sounds and intuitively knows that there is no difference of meaning signalled as is the case of pill and bill. Allophonic differences are the cause of the so called "foreign accent" in English and are important from the point of view of the programmer since incorrect programming of features can be misleading, especially to children. Table II lists the phonemes of English which have

TABLE II
ALLOPHONIC-PHONEMIC CORRESPONDENCES

PHONEME	ALLOPHONES	EXAMPLES
/p/	[p^h]	pit
	[p]	spot
	[p']	stop
/t/	[t^h]	tip
	[t]	stop
	[t']	spot
/k/	[k^h]	key
	[k]	skip
	[k']	lock

principle allophones. (The reader at this point should become familiar with Table II which will be the basis for future discussions and practice exercises.)

III.C. SUMMARY

To summarize:

1. Sounds of a language are represented by an "alphabet" of symbols not letters. The International Phonetic Alphabet was developed for this purpose.
2. If a sound in a language signals a different meaning it is representative of a phoneme class and as such is symbolized between two diagonal lines (//); e.g., /p/ in pill and /b/ in bill.

IV. STRESS PHONEMES IN ENGLISH

Up to this point the discussion has centered around consonant and vowel phonemes. There are three other types of phonemes called suprasegmentals. This section will deal with the type called stress, i.e., the force or accent given to syllables and words in English.

IV.A. STRESS PHONEMES

There are two general types of stress phonemes: emphatic and ordinary. As their respective names indicate, emphatic stress patterns are used when the speaker wishes to focus upon a word or phrase, normally adding emotional content to it; and ordinary stress patterns are those used in conversation to inform. In their own way these types of patterns are phonemic, because they too signal differences in meaning.

IV.B. TYPES OF ORDINARY STRESS

There are four degrees of stress used in ordinary speech, viz:

PRIMARY - The main stress in a word and the heaviest, most perceptible stress in a sentence. An example of primary stress in a word is that found on the first syllable of the word nation. If the reader pronounces this word he will hear the force put on the first syllable: NA-tion. If stress is put on the second syllable it will sound different: na-TION. The latter is not normal stress pattern for English words and a knowledgeable reader of the English language will sense it immediately.

SECONDARY - A stress used to distinguish groups of words which are taken as one unit (syntactic group) in a sentence. Consider the folowing examples:

a) Norm's car stalled in front of the White House. (particular house, syntactic group)

b) Norm's car stalled in front of the white house. (any house that is white)

The members of a syntactic group normally cannot be replaced. We could not, for example, say in front of the Red House, Blue House, etc., because White House refers to only one particular house, capitalized in writing to distinguish it from the generic term white (red, blue, brick) house. In the latter the noun "house" receives a main stress, whereas in White House, the first word has become part of a noun and therefore receives a noun (primary) stress. Other examples of such pairs are greenhouse vs. green house, blackbird vs. black bird, and blackboard vs. black board. Secondary

stress is found in noun-noun and adjective-noun combinations.

TERTIARY - A stress which may be described as one which aids speakers in pronouncing long words distinctly. Some examples: 1 3 elevator, 3 1 cybernetics.

WEAK - The stress or force accorded to all other (non-accented) syllables. Syllables which receive this stress (or lack of it) are normally reduced to /ə/. Examples of weak stress and how it reduces the vowel of a syllable are 1 4 3 telephone, 3 4 1 4 4 personality and 3 4 1 4 operation (In the last example notice that the stress on er is so weak that the syllable may be excluded without affecting comprehension: 3 1 4 opration

Programmers may use the numbers 1,2,3,4 to indicate the primary (1) to weak (4) degrees of stress.

IV.C. EMPHATIC STRESS

Emphatic stress patterns are not so much a type of stress as they are a deviation from stress patterns used in conversation. When speakers wish to convey a special meaning or focus on a particular word for the sake of contrast, they assign it main stress. For example, in the sentence:

1 1(s)
He ate my apple.

the reader will notice the primary stress on the verb ate and the primary sentence stress on the word apple. If the speaker wanted to make it unmistakeably clear that HE was the person who ate the apple (and not another person) the pattern could be changed to:

1(s)
He ate my apple.

where the sentence (primary) stress would be assigned to He, a pronoun which normally does not receive a main stress. Emphatic stress-

es are easy to locate and describe since they deviate from normal patterns, are often emotion-filled, and are generally articulated more loudly.

IV.D. STRESS AND VOWEL QUALITY

When a vowel receives a primary stress it is normally lengthened and tensed. Conversely, when a vowel receives a non-primary stress it reduces to the lax vowel of operation as discussed above. The programmer must take into account all the stresses which he determines when transcribing; if not, his output will not have the natural rhythm of English but will instead sound like a series of tape recorded words which have been spliced together, each vowel having the same length and quality. It is for this reason that the "Votrax-6" provides a series of optional input keys for the vowel phonemes. Some are for stressed vowels and others for less or unstressed vowels.

IV.E. SUMMARY

To. summarize:

1. Stress is the force or accent accorded to syllables in words and to words in sentences. It may convey information, as in ordinary conversation, or emotion, as in emphatically pronounced elements.
2. Vowel quality and length will vary, depending upon the stress assigned to it.
3. Certain types of words are never or rarely stressed. They are:

a. Auxiliary verbs- be, is, am, was, were, can,

could, would, shall, will, might, do,...

b. Definite and indefinite articles - a, an, the

c.Prepositions - of, for, about, by, ... as used in prepositional phrases.

4. Some main stress patterns for nouns are:

a. two-syllable - 1-4 (OB-ject, DIS-tance), exception: re-CRUIT

b. Three-syllable - 1-4-4 (HAP-pi-ness), 1-4-3 (CY-ber-speak)

5. Some main patterns for adjectives are:

a. two-syllable - 1-3 (LIVE-ly, PRET-ty)

b. three-syllable - 4-1-4 (un-HAP-py, dis-CORD-ant)

6. Some main stress patterns for adverbs are:

a. two-syllable - 1-3 (QUICK-ly, DEAD-ly)

b. three-syllable - 1-4-4 (PUR-pose-ly, RAP-id-ly)

c. four-syllable - 4-1-4-4 (un-HAP-pi-ly, un-COM-mon-ly)

For a detailed study covering exceptions to these patterns, the references cited in the Bibliography treat this question in an almost exhaustive manner. Programmers with no hearing impairment should be able to recognize stress patterns by recording typical messages and assigning stress patterns to the syllable and words as they perceive them on playback. Deaf-blind and deaf programmers would follow the algorithms established by the non-hearing impaired programmers.

V. JUNCTURE

One way to understand the term "juncture" in English is to relate it to the "space bar" on the typewriter. Note the examples:

1. Knickers are informal style.
2. Knickers are in formal style.

Only the spacing of sounds differentiates these two sentences, both of which are possible and sensible in the same context but only one meaning may have been correct or intended. Examples of juncture are uncommon in English, but the user/programmer should be aware of the existence of this phenomenon. Junctures are normally indicated by a plus sign between the appropriate sounds.

VI. PITCH PATTERNS

Pitch describes the rising and falling of the voice as speech is produced. It is used to distinguish statements, commands, and questions. For example, in the sentence, "John went fishing", it could be either:

1. John went fishing. (statement), or
2. John went fishing? (question)

depending upon the sequence of rising or falling pitch levels of the voice in the word "fishing". The numbers placed above various syllables indicate different pitch levels ranging from the lowest (1) to the highest (4). Level-2 is most often used as neutral "starting point" in speech. Pitch patterns are so complex and varied that no complete listing of them exists for the English language. To a certain extent variations in pitch patterns are the province of the individual speaker and vary much as two speakers' styles do. To better understand how to program a speech synthesizer the following section lists the most frequent, unambiguous patterns for American English. (For more detailed information consult the references cited in the Bibliography).

VI.A PITCH PATTERNS IN SIMPLE DECLARATIVE SENTENCES

The 2----3-1 pattern is the series most commonly used to indicate statements of information in the form of simple sentences. For example:

```
     2     3  1
1. It's raining
```

This is a simple sentence which communicates a fact without any emotion whatsoever. A statement which emphasizes words will vary from this pattern, but only slightly, as:

```
      3   2  2  2    3  1
2. Walt is a hard worker.
```

In this sentence both Walt and work receive a level-3 pitch, but for different reasons. Work is the syllable which was assigned the primary stress of the sentence-statement and Walt was assigned a level-3 pitch to signal its importance in the sentence. The sentence below is another example of the correlation between emphatic stress and rise in pitch or intonation (indicating emotion).

```
      3    2    3(s)   2    3   2   3(s)
3. John works hard, but Fred does not.
```

Here, the contrast between the two persons and the quality of their work is signalled to the hearer by changes in pitch level (rising to level-3) and by the use of emphatic stress.

VI.B. PITCH PATTERNS IN COMPLEX DECLARATIVE SENTENCES

A complex sentence is one in which a sentence is embedded within another.

For example:

```
     2  2   2   3 1
1. I saw the girl. (2----3-1 pattern)
       2  2    2   2       2  3    2       1
2. The girl was wearing a full length coat. (2-----3--1 pattern)
```

These two simple sentences may be rewritten into one complex sentence, as:

2 2 2 3 2 2 2 2 2 2 3 2 1
3. I saw the girl who was wearing a full-length coat.

Note that the pitch pattern for the complex sentence is almost identical to the patterns of the two simple sentences from which it is formed except that the first ---3-1 series becomes a ---3-2 series, indicating that the sentence is continuing. Notice that the phrase full-length was assigned a 3-2 pitch series. Often long compound adjectives which receive (syntactic group) 1-2 stress focus upon a particular word, and as such require an intonation pattern which brings them into the foreground. As the length of the sentence and/or its emotional content increases, so do the number of deviations from the unemotional, "bloodless" 2---3-1 pattern for statements.

VI.C. PITCH PATTERNS IN QUESTIONS

This section deals with three common types of questions and with different series of intonation patterns peculiar to each.

VI.C.1 PITCH PATTERNS IN RISING INTONATION QUESTIONS

This type of question, used only in informal conversation, has the same general form and word order as a typical statement, viz:

2 2 2 3 4
1. John went home already?

Only its intonation pattern differentiates this type of interrogative from a declarative sentence as in:

2 2 2 3 1
2. John went home already.

Notice that home would normally be assigned sentence stress and end-of-sentence pitch; however, since emphasis is on the time period involved (on one expected that John would be home so soon) already

receives an emphatic stress, and in this case is the prime candidate for the 3-1 and 3-4 end-of-sentence patterns.

VI.C.2 PITCH PATTERNS IN TAG QUESTIONS

A tag question is an interrogative sentence formed from a statement followed by a phrase such as isn't it, doesn't he etc. The sentence below is an example of such an interrogative.

1. John's typing, isn't he?

In this sentence, John's typing is the statement to which is added the tag isn't he: the latter indicates to the hearer that this utterance is a question.

Tags may be assigned one of two possible intonation patterns. If the speaker is not at all sure about his information he will verify his beliefs using a 2---3-4 series, as:

```
      2      2 2    3     4
```

2. John's typing, isn't he? (I thought I saw him at the typing desk.)

On the other hand, if the speaker is almost certain of his information he will verify it using a 2---3-1 series, as:

```
      2      2 2    3     1
```

3. John's typing, isn't he? (I saw him at the typing desk and hear the sound of the typewriter.)

Nuances such as these are often taken for granted by speakers and not consciously noticed; however, the programmer must not take anything for granted. He must carefully plot out the pitches assigned to each syllable. With practice it becomes an easy task.

VI.C.3 PITCH PATTERNS IN WH-WORD QUESTIONS

"Wh-word" interrogatives denote those questions which start with a form such as who, what, when, where, etc. Very often, but not always, the order of the subject and predicate of the sentence is inverted. An example of this is:

```
          2   2   2   3  1
1. What are you reading?
```

Since both the wh-word and the inverted word order signal to the hearer that the utterance is a question the pitch pattern is like that of a statement (2---3-1), unless emotion or emphasis are to be conveyed. The same question spoken in such a way as to show emotion would have a pitch pattern as shown below.

```
          3   2   2    3  1
2. What are you reading? (indicating surprise or possibly
   confusion)
```

As always, the programmer must examine each case individually in light of the information found in this manual as well as in other sources e.g., those listed in the Bibliography.

VI.D. PITCH PATTERNS FOR COMMANDS

Commands are most often expressed using a 2 or 3 level pitch in the beginning, depending upon intensity, with a 3---1 series at the end. As examples:

```
    31
1. Go.
   331
2. Go!!!
     2  3    1
3. Go downstairs.

     3  3    1
4. Go downstairs!
```

In situations where the command is paired with a statement, combine the pitch patterns, as with complex sentences (Section VI. B.), viz:

```
          3    2   2  31    2    2    2  3  1
5. Bring me the book that's on the table.
```

VI.E. SUMMARY

To summarize:

1. Pitch or intonation is the rising and/or falling of the tone of the voice used by the speaker to denote and distinguish statements, questions and commands and to signal the emotional content of an utterance.

2. There are four general levels of pitch in American English with level-2 being the usual neutral starting point in utterances.

3. Statements and individual words usually have a 2-3-1 pitch pattern in speech with level-3 accorded to the syllable receiving the main(sentence) stress and a lowering of pitch level-1 thereafter.

4. Questions may have different intonation patterns. Rising intonation questions have a 2-3-4 pattern analogously assigned as in (3.) above. Wh-word questions usually follow the 2-3-1 pattern as in statements since word inversion and the presence of the interrogative (wh-word) signals a request for information. Tag questions may have either a 2-3-1 or 2-3-4 pattern depending upon the degree of certainty which the speaker possesses.

5. Commands, for the most part, follow the 2-3-1- pattern of statements.

6. Intonation/pitch patterns vary slightly with each speaker, but in general are similar enough to enable communication among native speakers with occasional clarifications. The reader is encouraged to perfect or,at the very least, to ameliorate his perception of intonation patterns in speech in an effort to function more effectively as a programmer of the"Votrax-6."

7. Emotion, when communicated by pitch pattern, will normally be signalled by a rising intonation modifying the general scheme presented in this section.

VII. EXERCISE IN IDENTIFYING PHONEMES AND ASSIGNING STRESS AND PITCH PATTERNS

The reader's attention is directed to the exercise on the page following. This exercise is offered as a self-checking means of the degree to which the material presented herein has been retained by the reader. The answer key is on the page immediately following Exercise I.

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EXERCISE I (answers on following page)

NOTE: Do not write on this sheet. Use a separate sheet for your answers.

PART I. IDENTIFICATION OF PHONEMES AND ALLOPHONES

Directions: Refer to the list of Table I and identify the allophones that make up each of the words listed below. Separate the allophones with dashes.
EXAMPLE: television [t-ɛ-l-ɛ-v-I-$\overset{v}{z}$-ə-n]

1) push
2) goodness
3) pepper
4) contribute
5) pencil
6) cybernetics
7) children
8) ambition
9) dedication
10) happiness

PART II. ASSIGNMENT OF STRESS

Directions: Examine each of the following words and identify the syllable which receives the most stress by putting the number "1" above it.

1) persuade
2) national
3) macaroni
4) recorder
5) synthesizer
6) technology
7) government
8) education
9) cheerfulness
10) purpose

PART III. PITCH PATTERNS

Directions: Considering the manner in which the following sentences would normally be uttered, indicate whether each ends with a rising or falling pitch with an "R" or an "F" respectively.

1) It's raining.
2) Hard work pays off.
3) Who is he?
4) John left home already?
5) Let's meet at the store.
6) They have five books.

Check your answers with those on the page following. Reread the appropriate sections of this manual where errors indicate such a need.

ANSWER KEY FOR EXERCISE I

NOTE: Do not write on this sheet. Use a separate sheet for your answers.

PART I. IDENTIFICATION OF PHONEMES AND ALLOPHONES

Directions: Refer to the list of Table I and identify the allophones that make uo each of the words listed below. Separate the allophones with dashes.
Example: television [t-ɛ-l-ɛ-v-I-$\overset{v}{z}$-ə-n]

1) push [p-U-s]
2) goodness [g-U-d-n-ɛ-s]
3) pepper [p-ɛ-p-e^{r}]
4) contribute [k-a-n-t-r-I-b-yu-t]
5) pencil [p-ɛ-n-s-I-l]
6) cybernetics [s-ay-b-e^{r}-n-ɛ-t-I-k
7) children [$\overset{v}{c}$-I-l-d-r-ɛ-n]
8) ambition [ae-m-b-i-$\overset{v}{s}$-ə-n]
9) dedication [d-ɛ-d-ə-k-e-$\overset{v}{s}$-ə-n]
10) happiness [h-ae-p-i-n-ɛ-s]

PART II. ASSIGNMENT OF STRESS

Directions: examine each of the following words and identify the syllable which receives the most stress by putting "1" above it.

1) $\overset{1}{\text{persuade}}$
2) $\overset{1}{\text{national}}$
3) $\overset{1}{\text{macaroni}}$
4) $\overset{1}{\text{recorder}}$
5) $\overset{1}{\text{synthesizer}}$
6) $\overset{1}{\text{technology}}$
7) $\overset{1}{\text{government}}$
8) $\overset{1}{\text{education}}$
9) $\overset{1}{\text{cheerfulness}}$
10) $\overset{1}{\text{purpose}}$

PART III. PITCH PATTERNS

Directions: Considering the manner in which the following sentences would normally be uttered, indicate whether each ends with a rising or falling pitch with an "R" or an "F" respectively.

1) It's raining. F
2) Hard work pays off. F
3) Who is he? R
4) John left home already? R
5) Let's meet at the store. F
6) They have five books. F

If more help is needed than this manual offers, check the bibliography for references.

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VIII. PROGRAMMING THE "VOTRAX-6" SPEECH SYNTHESIZER

The purpose of this section is to provide additional procedures to facilitate the programming of the "Votrax-6". For more infomation refer to the manufacturer's manual for the detailed mechanics of the operation (sound level and speech rate controls, keyboard entry, etc.) of this device. It may be noted that using the standard "Votrax-6" keyboard one can program pronounciation of all English words in common Mid-West American dialect. Since the synthesizer does not make provision for stress, stress assignment is handled by lengthening the vowel which would normally be intensified in speech, often coupled by a rise in pitch or intonation level.

VIII.A. ALLOPHONE-KEYBOARD CORRESPONDENCES FOR CONSONANTS

The correspondences between consonant allophones and keys of the"Votrax-6"are rather straight forward in most instances. Table III is a list of these relationships. Note that the alphabetic letters C, Q, and X are not on the keyboard. This is because phonetically they correspond to [k] or [s], [k] or [k-w], and [e-k-s], respectively.

A number of "rules" to cover special cases are helpful when programming consonants. These are not essential to achieving understandable speech, but will generally enhance its intelligibility. These are:

1. As shown in Table III, a [t] at other than the beginning or end of a word should be programmed with the key DT.

2. A [č] at other than the beginning of a word should have the CH preceded by a T.

TABLE III

ALLOPHONE-KEYBOARD CORRESPONDENCES FOR CONSONANTS

ALLOPHONE	EXAMPLE	KEY
p^h	pill	P+space
p	spot	P
b	bill	B
t^h	till	T+space
t	still	T
	water	DT
d	dill	D
k^h	kill	K+space
k	skip	K
g	gill	G
f	fill	F
v	ville	V
θ	the	TH
ð	those	THV
s	sill	S
z	zeal	Z
$\overset{v}{s}$	shall	SH
$\overset{v}{z}$	rouge	ZH
$\overset{v}{c}$	chill	CH
$\overset{v}{j}$	jill	J
l	lill	L
r	rill	R
ŋ	sing	NG
h	hill	H
w	will	W
y	yes	Y1

3. A word ending in [t], [k], or [p] should be followed by a SPACE to prevent the "clipping" of these sounds.

4. The allophone [J̌] should usually be programmed as D+J rather than simply as J, especially at other than the start of a word.

VIII.B. ALLOPHONE-KEYBOARD CORRESPONDENCES FOR VOWELS

Table IV is a list of the allophone-keyboard correspondences for vowels. The listed keys are generally representative of the vowel lengths normally used and are listed with the longest sound first. Slightly more elegant speech can be produced in some cases using as many as three keys per allophone, but the tabulation shown is based on the use of a maximum of two keys per allophone. This was done to conserve memory space in the "Votrax-6" and to simplify the programming process with very little compromise with regard to speech intelligibility. The underlined keys can be used as a "starting place" for the serious programmer or as a minimal set for the production of speech which will prove to be satisfactory for all but the most critical applications. This minimal set forms the basis for Table IV-A.

VIII.C. THE USE OF SPACE AND PAUSE

Two keys of the "Votrax-6", the space bar and PA1, can be used to produce pauses in its programmed synthetic speech. The space bar, hereafter referred to as PAØ, produces a pause equivalent in length to the shortest vowel sounds while that generated by the use of PA1 is four times this length, or about the length of the longest vowel sounds. As a general rule, pauses need not be programmed between each word in phrases or sentences. The chief exception to this is noted above with regard to words which end in t, k, or

TABLE IV

ALLOPHONE-KEYBOARD CORRESPONDENCES FOR VOWELS

ALLOPHONE(S)	EXAMPLE	KEY(S)
[i]	beat	E, E1, Y
[I]	bit	I, I1, I2, I3
[e]-[ey]	bait	A+Y, A1+Y, A1+AY, A2+AY
[ɛ]	bet	EH, EH1, EH2, EH3
[ae]	bat	AE, AE1
[a]	hot	AH, AH1, AH2
[ay]	bite	AH+Y1, AH1+Y, AH1+Y1, AH2+Y1
[ɔ]	bought	AW, AW1, AW2
[o]-[ow]	boat	O+U1, O, O1, O2
[ɔy]	toy	O+E, O+Y, O+Y1, O1+Y
[U]	put	OO, OO1
[u]-[uw]	moon	U+W, U1+W, U, U1
[ə]	but	UH, UH1, UH2, UH3
[au]	gouge	AH+U, AH+U1, AH1+U1, AH2+U1
[yu]	use	Y1+U, Y1+U1
[e^r]	fur	ER, R

Notes: 1. Key listings are ordered from longest to shortest sound.

2. Underlined key(s) indicate reasonable choices for most circumstances.

3. See word vocabulary provided with Votrax-6 for more elegant allophone production utilizing up to three keys per allophone.

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TABLE IV-A

MINIMAL ALLOPHONIC-KEYBOARD GUIDE FOR VOWELS

ALLOPHONE (S)	EXAMPLE	KEY(S)
[i]	beat	E1
[I]	bit	I2
[e]-[ey]	bait	A1+AY
[ɛ]	bet	EH1
[ae]	bat	AE1
[a]	hot	AH1
[ay]	bite	AH1+Y1
[ɔ]	bought	AW1
[o]-[ow]	boat	O1
[ɔy]	toy	O+Y1
[U]	put	OO1
[u]-[uw]	moon	U
[ə]	but	UH1
[au]	gouge	AH1+U1
[yu]	use	Y1+U1
[e^r]	fur	ER

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p. Juncture, the temporal delay between segments is handled by use of PAØ. To distinguish between pairs like nitrate and night rate, simply introduce a PAØ at the appropriate point in the word. Pauses represented in ink font by commas and periods are generated by the use of the PA1 key.

VIII.D. INTONATION

Four levels of intonation are provided by the "Votrax-6". These four levels, lowest to highest, are produced through the use of the intonation keys IN1, IN2, IN3, and IN4, The appropriate intonation key must be held actuated while the desired allophonic key is being operated. If no intonation key is used the allophone will be produced at intonation level 1. As discussed earlier, intonation is used as an adjunct to vowel length to provide stress patterns in the synthetic speech of the machine, although pitch patterns are associated with vowels sounds in English speech, characteristics of this synthesizer require that consonants be considered in the intonation process. The designof this machine is such that any programmed change in the level of intonation is not effective in the output until one-half or a full phoneme later. Thus to ignore consonants when programming intonation patterns will result in speech output which may not be natural in sound.

VIII.E. SIMPLIFIED PROGRAMMING

Through the use of vowels of varying length and intonation patterns, the "Votrax-6" is capable of producing synthetic speech which is of unusually high quality with respect to intelligibility and naturalness of sound. However, when communication per se is paramount as opposed to the generation of the most natural speech

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possible, much of the most time-consuming aspects of programming, the vowel length selection and intonation patterning, can be dispensed with. The result will be a monotonic machine-like speech, but the effectiveness of the synthesizer as a communication device will be impaired very little. The keys to simplified programming are the Minimal Allophonic-Keyboard Guide for Vowels of Table IV-A and the exclusive use of intonation level 1.

VIII.F. PROGRAMMING PROCEDURE AND EXAMPLE

The formal programming pratices presented here will allow even the most uninitiated to generate natural sounding synthetic speech with the 'Votrax-6'. Initially, several iterations will probably be required to reach the desired degree of naturalness, but with practice, the level of formality and the number of iterations can be reduced significantly. The steps below are illustrated in Figure 1 as an example.

1. Write the message twice leaving space for intonation and stress pattern designations above each line.
2. Using the information and examples of Sections IV and VI of this manual identify and indicate the stress and pitch patterns of the message. Use the first copy for stress patterns and the second for pitch. It is heplful here to use a tape recorder so that the message can be played several times to facilitate the identification of these patterns.
3. Using the information in Section III and Tables I and II as a guide write the message using the appropriate allophones.

4. Using the information of this section (VIII) and Tables III and IV as a guide write the message using key symbols of the "Votrax-6" keyboard. Remember to select vowel lengths for Table IV in accordance with the stress patterns previously determined. Include pauses (PAØ and PA1) where required as part of this process. Separate the key terms by dashes for for the sake of clarity.

5. Write the previously determined intonation patterns above the key symbols of the message.

6. Program the "Votrax-6" with the message and critically analyze the result, making notes as to any shortcomings. Modify the program as required and try again. Repeat as often as necessary until the desired result is obtained.

VIII.G. SIMPLIFIED PROGRAMMING PROCEDURE AND EXAMPLE

Below is a formal procedure for accomplishing the simplified programming discussed above in Section VIII.D. With only a little practice the reader will find that it is a relatively simple matter to go directly to the keyboard and start programming rather than first going through the process of actually writing the message, identifying the allophones, and subsequently the key symbols. The steps below are illustrated in Figure 2 as an example. Comparisons should be made with messages programmed according to the section above.

1. Write the message.

2. Using the information in Section III and Tables I and II as a guide write the message using the appropriate allophones.

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3. Using the information of this section (VIII) and Tables III and IV-A as a guide, write the message using the key or interface assigned to the symbols of the speech synthesizer. Include pauses (PAØ and PA1) where required as part of this process. Separate the key terms by dashes for the sake of clarity.

4. Program the speech synthesizer with the message.

```
 3  1   1  2  2  2   3   1  1     3 1   (pitch)
Washington is an extremely large city.

 1  4   4  4  4  3  1(S) 4  4     1 4   (stress)
Washington is an extremely large city.

[wɔsIntən+IzaenɛkstrimlilarˇjsIti]       (allophones)

3  2  1  1  1  1  1  1  1  2  2  2  2   (intonation)
W-AW1-SH-I3-NG-T-UH3-N-PAØ-I2-Z-AE1-N-  (key symbols)

 2  2 2 2 3 2  2 1 1 1  1  1 1 1 3 2  1 1
EH3-K-S-T-R-E1-M-L-Y-L-AH2-R-D-J-S-I3-T-Y
```

FIGURE 1. A PROGRAMMING EXAMPLE

```
Washington is an extremely large city.  (message)

[wɔsIntən+IzaenɛkstrimlilarˇjsIti]       (allophones)

W-AW1-SH-I2-NG-T-UH1-N-PAØ-I2-Z-AE1-N-  (key symbols)

EH1-K-S-T-R-E1-M-L-E1-L-AH1-R-D-J-S-I2-T-E1
```

FIGURE 2. A SIMPLIFIED PROGRAMMING EXAMPLE.

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Appendix B

PHONEMES

It has been estimated that there are about 3,000 languages spoken on our planet, many of which do not have a writing system; therefore, communication through numerous languages in a written form is not possible.* However, for those languages which do have established writing systems, sets of signs or symbols known as "graphemes" are employed and have assigned usages. These graphemes represent either a morphemic or phonemic reference. For example, the English word "tax" represents a set of three Latin graphemes of various subtypes of phonemic reference, all within the English written system. The phonemic reference of "t" is /t/ and may have slight variations, but these are essentially of no consequence. However, the reference of "a" in this instance is /æ/; it is really misrepresented by the grapheme "a". Similarly, the reference of "x" is /ks/, in reality a sequence of two phonemes. This and similar examples demonstrate intricacies which prevail between English writing systems and English phonology.

The English symbol "&" (ampersand), on the other hand, represents a reference to the morpheme "and", or when translated into the phonemic reference, /ænd/. Note that the symbol "&" does not graphically represent a sequence of phonemes, since only one graphic symbol is discerned. If the symbology did represent the three phonemes /æ/,/n/, and /d/, then spellings such as "h&" for "hand", "s&" for "sand", "&rew" for "Andrew" might be appropriate. Hence, this particular grapheme clearly has only a morphemic reference.

Graphemes with morphemic reference which represent an idea are called ideograms. There are writing systems which use ideograms, one of which is Chinese, where most of the graphemes have morphemic references. However, in most of the normal writing systems, graphemes have references within the phonologic system of the given spoken language.

Individual phonemes have individual graphemes, or individual graphemes may represent a sequence of phonemes. The first system is referred to as "alphabetic writing" such as in English, and the latter as "syllabic writing," of which Japanese is a good example.

English has a phonemic system in which subsystems are distinguished. The phonological analysis of the vowels presents difficulties in English. Most Americans and Britishers have the very same total of vowel phonemes in their phonology, although their description varies from dialect to dialect.

In studying the characteristics of any spoken language, linguists initially determine its phonemes. To do this, they compare and examine samples of the spoken language in question to ascertain words which are distinct in expression and in content without reference to context. Two minimally different samples which denote differences of content and expression are commonly called a minimal pair. By establishing the differences of minimal pairs, it is determined whether given phonemes in the given pair contrast in meaning and expression, e.g., bill – pill; chill – jill; till – dill; pet – bet; wet – yet; met – net.

In English, there are 9 simple vowels and the following 24 consonant phonemes.†

/b/ as in bill	/t/ as in till
/d/ as in dill	/v/ as in ville
/f/ as in fill	/w/ as in will
/g/ as in gill	/y/ as in yet
/h/ as in hill	/z/ as in zeal
/k/ as in kill	/θ/ as in thigh
/l/ as in lill	/ð/ as in thy
/m/ as in mill	/š/ as in shall
/n/ as in nil	/ž/ as in rouge
/p/ as in pill	/č/ as in chill
/r/ as in rill	/ǰ/ as in jill
/s/ as in sill	/ŋ/ as in sing

In order to demonstrate the distinction between each of the aforementioned phonemes, numerous minimal pairs are available with the exception of a few consonant phonemes, such as

*Joshua Whatmough, Language: A Modern Synthesis, (New York, Mentor Books, 1960).

†George L. Trager and Henry Lee Smith, Jr., An Outline of English Structures, 3d Printing – American Council of Learned Societies, Washington, D.C., 1957.

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/θ/ and /ð/, or /ʃ/ and /ʒ/. In the case of /θ/ and /ð/, only five minimal pairs are commonly known: thigh – thy: ether – either; mouth (noun) – mouth (verb); wreath – wreathe; thistle - this'll. The phoneme /ʒ/ in English occurs rarely e.g., dilution – delusion; glacier – glazier. Similar difficulties arise in the study of other languages. Hence, it is sometimes necessary to use other methods than simply the finding of minimal pairs.

One of these methods is articulatory phonetics. It is based on the assumption that characteristics of speech sounds are the result of the manner by which the very speech sounds themselves are formed. These characteristics are commonly described and classified in accordance with the position and action of human speech organs. In acoustic phonetics, investigators analyze speech sound through the study of linguistically significant features of speech from an acoustic viewpoint. Thus, the consonants may be grouped as follows:

Resonants:
nasal - /m, n, ŋ/,
lateral - /l/, and
median* - /r, y, w/,

Fricatives:
voiceless - f, θ, s, ʃ/,
voiced - /v, ð, z, ʒ/.

Stops:
voiceless - /p, t, k/,
voiced - /b, d, g/.

Affricates:
voiceless - /ʧ/ and
voiced - /ʤ/.

*All English vowels are median resonants.

LANGUAGES EXAMINED AND APPROXIMATF NUMBER OF USERS

A.	Indo-European	
	1. Germanic	
	(a) English	400,000,000
	(b) Dutch	15,000,000
	(c) German	90,000,000
	(d) Danish	5,000,000
	(e) Norwegian	3,500,000
	(f) Swedish	7,500,000
	(g) Yiddish	5,000,000
	1.1 Greek	11,000,000
	2. Romance	
	(a) Classical Latin	---
	(b) Italian	55,000,000
	(c) Spanish	120,000,000
	(d) Portugese (incl. Brazil)	80,000,000
	(e) Rumanian	20,000,000
	(f) French	60,000,000
	3. Slavonic	
	(a) Serbo-Croatian	20,000,000
	(b) Polish	35,000,000
	(c) Russian	200,000,000
	(d) Other	10,000,000
	4. Indo-Iranian (Persian, Pachtu Afghan)	45,000,000
	5. Armenian	5,000,000
B.	Finno-Ugrian	
	1 Hungarian	10,000,000
	2. Finnish	4,500,000
C.	Turkic	
	1. Osmanli	30,000,000
	2. Azeri	5,500,000
D.	Semitic	
	1. Egyptian/Arabic	30,000,000
	2. Amharic	20,000,000
	3. Hebrew	3,000,000
E.	Sino-Tibetan	
	1. Mandarin (Chinese)	500,000,000
	2. Japanese	100,000,000
F.	Indonesian	90,000,000
G.	Swahili	10,000,000
	TOTAL	1,992,000,000

CHART OF AGGREGATED CONSONANT PHONEMES

VL = VOICELESS
VD = VOICED

POINT OF ARTICULATION	MANNER OF ARTICULATION									
	STOPS		AFFRICATES		FRICATIVES (SPIRANTS)		TRILLS	LATERALS	NASALS	SEMI-VOWELS
	VL	VD	VL	VD	VL	VD				
BI-LABIAL	p p'	b b'			ɸ	β			m	w
LABIO-DENTAL					f	v				
INTER-DENTAL					θ	ð				
DENTAL	t t'	d d'								
PRE-ALVEOLAR			c ɕ	ʒ			r̃	l	n	
ALVEOLAR					s	z	r			ɹ
POST ALVEOLAR (PRE-PALATAL)			ʧ ʨ	ʤ	ʃ	ʒ		ʎ	ñ	y
PALATAL	kʸ	gʸ								
VELAR	k k'	g g'			x	ɣ		ɬ	ŋ	
UVULAR	q					ʁ				
PHARYNGEAL						ʔ				
LARYNGEAL	ʔ				h	ɦ				

All the consonants are characterized by closure or narrowing at some point in the mouth and are classified by this point of articulation.

In each case there are two parts which are called articulators, and they are brought together when we speak or utter words.

In the English language, stress and intonation are phonemic.

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CHART OF AGGREGATED VOWEL PHONEMES

	POINT OF ARTICULATION			
	FRONT		CENTRAL	BACK
	UR	R	UR	R
HIGH	i	ü	ɨ	u
MID-CLOSED	e	ö	ə	o
MID-OPEN	ɛ	ɔ̈		ɔ
LOW	æ		ɑ	a

R = ROUNDED
UR = UNROUNDED

MODIFIERS
: = LENGTHENED
¨ = LABIALIZED
~ = NASALIZED

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Appendix C

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PROPOSED MEETINGS

It has been a continuous aim of C/R/I to ensure that the results of this work be available to as many potential users as possible and that only a small delay exist between the development stage and utilization in actual rehabilitation situations. The letter in Appendix C shows one of several seminars which have been arranged by C/R/I to convey the findings to others. Many of C/R/I's results can already be applied to ongoing rehabilitation programs. C/R/I's work on the synthesis of speech and on telephone controlled braille equipment (See Figure VI) serves as two examples.

> *"There is a great diversity in the combination of defects in cases of multiple impairment of higher mental functions involving damage to hearing or sight. In such cases, it is not sufficient to use the standard methods of conventional special education and the corresponding equipment."*
>
> I.V. Tsukerman
> Excerpt from an article "Aids for Children with Multiple Handicaps" Translated from Soviet Education 14, No. 1-2-3, Nov., Dec., Jan., 1971/72, p.183, Institute of Defectology of the U.S.S.R., Academy of Pedagogial Sciences.

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STATE OF SOUTH CAROLINA
DEPARTMENT OF MENTAL RETARDATION

HERBERT F. CICENIA, Ed.D.
Superintendent

CHARLES D. BARNETT, Ph.D.
State Commissioner
of Mental Retardation

COASTAL CENTER
JAMISON ROAD
LADSON, SOUTH CAROLINA 29456
August 11, 1975

Mr. Haig Kafafian, Director
Cybernetics Research Institute
2223 Wisconsin Ave., N. W.
Washington, D. C. 20007

Dear Haig:

Dr. Cicenia, our Superintendent, and I are both interested in pursuing with you the possibility of our being one of the original centers to work on the Deblicom Project that you are developing. I think it is a good idea for you to have those interested personnel meet at Cybernetics Research Institute in Washington prior to the American Speech and Hearing Association Convention in November. Our convention begins the morning of the 21st; therefore I would like to suggest to you at this time that the 19th and 20th of November would be a good time to have a meeting at Cybernetics in regards to the Deblicom Project.

I feel sure that I could make arrangements to come to Washington early before the convention to work with you at the Institute.

I am looking forward to seeing you in November and hearing from you soon.

Sincerely,

Rosalyn

Rosalyn K. Monat, M.Ed.CCC-Sp.
S. C. License No. 17
Director, Speech and Hearing

cc: Dr. Cicenia

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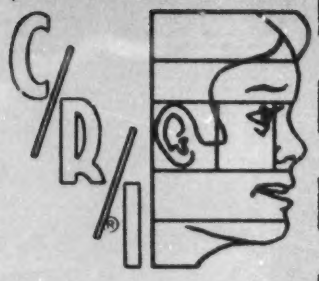
CYBER-GRAM



VOL.1 AUGUST 1975 NO.5

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DEBLICOM

As a result of visits to centers (see attached news clippings) and communications with workers in the field, we have prepared a preliminary basic list of messages which deserve consideration for DEBLICOM's (Communications and Control Systems for Persons who are Deaf-Blind) message board.

If you have any suggestions, let us know what you would add or delete.

1. HELP
2. NO
3. YES
4. BATHROOM
5. TIME?
6. HUNGRY
7. THIRSTY
8. HUG ME
9. NOT ON LIST*
10. REPEAT
11. UNCOMFORTABLE
12. SOMETHING BURNING
13. HOT
14. COLD
15. SICK
16. MEDICINE DISAGREEABLE
17. MOVE FEET
18. CONSTIPATED
19. WASH FACE
20. T.V.*
21. MEDICINE TIME
22. YOUR NAME?
23. BRUSH TEETH
24. RECORD*
25. I HAVE A COLD
26. SOMETHING IN EYE
27. STOMACH HURTS
28. SORE THROAT
29. LIE DOWN
30. BLOW NOSE
31. BECAUSE
32. NEWSPAPER, MAGAZINE*
33. CHEST PAIN
34. BUTTON, ZIPPER
35. I LIKE YOU
36. NOSE ITCHES
37. ACHE
38. LIGHT*
39. AFRAID
40. SHOW ME
41. TYPE, OR USE ARTIFICAL VOICE
42. SICK STOMACH
43. TIRED
44. WINDOW (OPEN/CLOSE)
45. TELEPHONE*
46. TURN PAGE*
47. CHANGE CHANNEL-RECORD-STATION*
48. DIARRHEA
49. YOUR NAME?
50. I'M HAPPY (STAY WITH ME)
51. I'M SAD/ANGRY (GO AWAY)
52. MOTHER
53. FATHER
54. CHURCH, TEMPLE
55. READ BOOK *
56. READ MAGAZINE *
57. WHO?
58. WHEN?
59. WHY?
60. HOW?
61. WHERE?
62. WHAT?
63. THANK YOU

* FOR PARTIALLY DEAF OR BLIND PERSONS

REQUESTS

1. There have been many requests for the translation of Tsukerman's article on CYBERTYPE®. The accompanying translation is for your information.

2. If you want to attend the DEBLICOM meeting Nov.19-20 prior to the American Speech and Hearing Association Convention (See Roslyn's letter) please let us know as soon as possible.

® Cyber Corp., Washington, D.C.

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Translated From DEFEKTOLOGIIA, 1971, NO.3
Soviet Education 14
No. 1-2-3. Nov., Dec., Jan., 1971/72

Aids For Children With Multiple Handicaps

by I. V. Tsukerman

There is a great diversity in the combination of defects in cases of multiple impairment of higher mental functions involving damage to hearing or sight. In such cases, it is not sufficient to use the standard methods of conventional special education and the corresponding equipment.

The American Cybernetics Research Institute in Washington has undertaken the development of a general-purpose system (a) enabling children with combinations of defects to transmit and receive alphabetic information with the aid of a special typewriter. A complex series of devices has been developed, and with slight adjustments the system can be adapted to meet the needs of the child's particular defects. The Cybertype ® a cybernetic typewriter — is the main element in the complex. The system incorporates 12 different devices and can be used by children with such complex defects as deafness accompanied by partial paralysis, blindness coupled with impaired coordination of movement or the absence of hands (amputation), etc. For the most part, the cybernetic communication devices are adjusted through the replacement of individual units.

The leading component in the system is the Cybertype

The author is affiliated with the Institute of Defectology of the USSR Academy of Pedagogical Sciences.

® Cyber Corp., Washington, D. C.

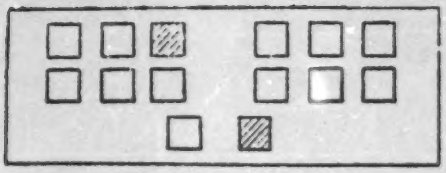

Fig. 1. Schematic of layout of keys in a 14-key system. The shaded squares show keys that are pressed in transmitting the letter R.

keyboard, which serves as the input for coded information. It consists of 14 keys — 7 for each hand (see Fig. 1). The keys are arrayed in three rows: the upper two rows have 3 keys each for the index, middle, and ring finger; the lower rows consist of 1 key each, which is operated by the thumb. The overall area of the keyboard is six times smaller than the keyboard of a standard typewriter, which numbers 49 keys, and its area is approximately 40 square centimeters instead of the 240 square centimeters for a conventional typewriter. The reduction in the number of keys and in the keyboard area is especially important for children with impaired coordination of movement.

Letters, numbers, and punctuation marks are transmitted through the simultaneous depression of two keys. Each semantic sign has its own combination which is determined by a two-position cybernetic code especially developed for this purpose. In Fig. 1, the shaded squares show the keys that are depressed to transmit the letter R.

The possible number of binary combinations for n = keyboard system is 91 if n = 14. Such a number of combinations is valid for the simultaneous depression of any pair of keys in the entire 14-key system. If the task is limited to the simultaneous depression of one key on the right and one on the left side of the keyboard, the possible number of combinations is reduced to $7 \times 7 = 49$. This number corresponds exactly to

the number of keys on a standard typewriter, and is entirely sufficient for the transmission of all letters, numbers, and basic punctuation marks.

The coded signals are transmitted from the keyboard to the reproduction device through electrical and mechanical transformations. Alphabetic information can be reproduced either in the form of an ordinary, flat-printed text on an electric typewriter or in the form of illuminated letters on a lighted panel.

For the blind, the information output is in the form of a text written in Braille, and where necessary, the text is duplicated in flat-printed form.

In addition to the resolution of technical difficulties, the development of cybernetic communications devices was also aimed at the composition of a rational and sufficiently simple two-position code that could be assimilated by abnormal children. It was also necessary to conduct a training experiment and determine particulars and specific conditions for which the given devices can be recommended.

Principles in the Organization of the Code

The following three most important factors determining the effectiveness, convenience, and simplicity of application were considered in compiling the two-position cybernetic code: the simplicity of use of letters in the English language, the most common two- and three-letter combinations, and the maximum use which can be made of these combinations.

Investigation of the frequency of use of letters in the English language, the findings of which are presented in monographs by H. S. Zim and J. R. Pierce (2), made it possible to compile the following descending series: **E, T, A, O, N, I, R, S, H, D, C, L, M, U, F, P, Y, B, G, W, V, J, K, Q, Z, X.**

Knowledge of the most frequent two- and three-letter combinations (digraphs and trigraphs) is essential for a convenient arrangement of the keys so as to reduce the movement of hands to a minimum in the typing process. (3)

A detailed study was made of the use frequency of digraphs and trigraphs. The following important fact was discovered: a mere 11 digraphs out of a million comprise 25 percent of the usages. It was also determined that 34 digraphs account for 50 percent of the usages, 57 for 75 percent, and 137 for 90 percent. The following indices were established for trigraphs: 22 trigraphs — 25 percent, and 104 — 50 percent of the usages. Data are also obtainable for tetragraphs (four-letter combinations): 46 tetragraphs — 25 percent, and 208 — 50 percent of the usages out of a million. While we did not find analogous data for the Russian language, it can be anticipated that these patterns would not differ strikingly from English. These data are of vital importance for the theory and practice of coding verbal information.

Instruments in the Cybernetic Communications System

A device designed for the deaf is shown in Fig. 2. It is called a cybernetic lamp. Information is transmitted by a 14-key system using a two-position code. The "output" consists of a lighted panel displaying dactylogical signs. When a certain letter is transmitted, it lights up. For monitoring of a transmitted message, the message is duplicated in the form of a flat-printed text on an electric typewriter. Such an apparatus

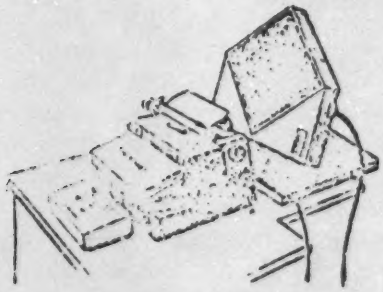

Fig. 2. Cybernetic lamp.

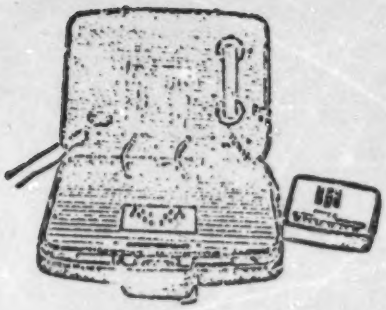

Fig. 3. Cybernetic telephone.

can be recommended for communicating with deaf children afflicted with impaired coordination of movement, partial paralysis, or hands amputated at the wrist. In the latter case, the keys are replaced by so-called semaphor control — multipositional levers (like the gearshift of an automobile).

Another modification of cybernetic communications devices — a special telephone known as the Cyberphone® — is designed for deaf persons with normal vision as well as for persons with speech defects (see Fig. 3). It uses an ordinary telephone set to which cybernetic communications equipment performing coding and recoding operations is connected. The same 14-key system is used for the input of signals. All components are combined in a single housing. Communication is effected using conventional telephone lines. At the receiving end, the decoding mechanism decodes the signals that reach the lighted panel and lights up the corresponding letters. All letters of the alphabet, numbers, and punctuation marks are outlined on a small rectangular lighted panel measuring 17.5 centimeters to a side. The Cyberphone is still in the initial stages of experimental testing.

Fig. 4 shows one of the devices designed for the blind — a cybernetic plate. It differs from the devices described above by virtue of its keyless information input system. It employs

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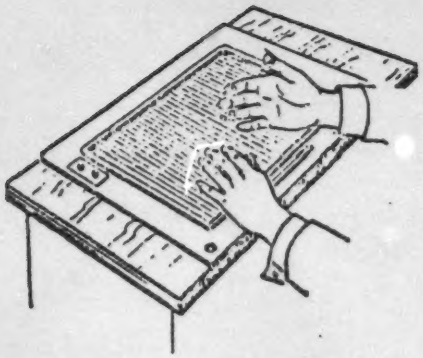

Fig. 4. Cybernetic plate for the blind.

the same principle as the keyboard system, but instead of using keys to close the circuit, it employs sensors in the form of unique contacts that are attached to the fingers or to a special glove. The contacts can be applied to any area on the plate. Contacts are attached to the fingers in a specific way: two contacts on each index, middle, and ring finger, and one contact on each thumb. In all, there are seven sensitivity points on each hand. The use of sensors in accordance with the adopted cybernetic code makes it possible to produce the same result achieved through the use of the 14-key system. In the case of blind children whose motor sphere is impaired, the advantages of the keyless system, which obviates the need to search for a given key, are evident. Experience has shown that upon mastering the transmission of information through the glove, the blind readily make the transition to typing with the 14-key system, and virtually no additional training is required.

The Cyberbrailler is one of the most complex devices in the class of equipment under examination. It is designed for the blind and for typhlopedagogues learning Braille. The device makes it possible to produce simultaneously two texts printed by different methods — flat print and raised-point print. The Cyberbrailler can be recommended for producing various texts

for the blind. Signals are also fed into the device with the aid of the 14-key system. In the opinion of the designers, blind persons capable of typing on a Braille typewriter readily master the technique of typing with the 14-key system, since the conditions and requirements are similar in both cases.

Training Materials and Experimental Methods

In order to elaborate methods of operating the cybernetics communications devices, typing instruction was offered using the 14-key system. The experimental group consisted of children between the ages of 7 and 12 years. In five of them, the principal defect was damage to the motor sphere accompanied by deafness, blindness, or speech defects. One child (7 years of age) had no hands, and the coordination of movement was impaired in three blind children. As an exception, there was one adult — a war veteran who was practically blind and whose hands had both been amputated. There were a total of ten trainees. Exercises were conducted individually for each trainee for half an hour a day twice a week for at least five months. The assignment of the trainees was to memorize the cybernetic code and to achieve automatic skills in its transmission. The sequence of studying the letters was based on the frequency of their use in the English language. After familiarization with the arrangement of the keys corresponding to specific letters or numbers, supplementary exercises were given in the form of words and phrases consisting of assimilated letters. There were also special exercises to develop the speed, precision, and rhythm of transmission. Two lists of words were compiled, one consisting of words known to the children and the other consisting of relatively unfamiliar words. The latter was intended to expand the children's vocabulary. In addition, phrases were selected for letters already studied.

Memorization of the new code, which is abstract in its structure, presents a certain difficulty for young children. Therefore, a visual aid — a cybernetic circus — was designed to facilitate assimilation. The circus consisted of a toy arena

with a screen from behind which appeared fairy tale or circus figures well known to the children. Brightly colored figures appeared only when the corresponding keys were correctly depressed. Thus, when the A key was depressed, the Anna doll appeared, for the T key, the Tom figure, etc. The figures were removable and came in several varieties, and the pedagogue himself could select different figures in keeping with the child's vocabulary.

As a rule, the training of the blind commenced with the assimilation of the use of the cybernetic plate and the cybernetic glove. They were given an understanding of which combinations of contacts with the plate corresponded to a given letter. The same training material was used as was employed for the 14-key system, to which they converted after mastering transmission on keyless devices. It was demonstrated that in the process of mastering the code, words are assimilated as a sequence of pairs of key combinations. When a blind girl with impaired speech was verbally asked how to write the word ate, she silently indicated the binary combinations of keys corresponding to the letters a, t, e. (4)

In the process of recording the results of training, the overall period of training, the number of keys pressed per lesson, and the number of erroneously pressed keys were taken into account. The direction of mistakes — horizontal or vertical — and mistakes in code were noted. Errors were calculated in terms of thousands of binary hits, i.e., the number of errors per 1000 letters. During the first lesson, the average number of hits per pupil was roughly 120, of which approximately 30 were errors. The duration of the training course varied from 11 to 14.5 hours and was determined on the basis of difficulties engendered by the structure of the principal defect. The longest period of training (14.5 hours) was for a deaf child with cerebral palsy and speech defects.

In selecting the keyboard for each child, consideration was given to the movement of arms, prosthetics, and the range of their effect. In keeping with such individual features, the type of keyboard (divided or integrated), the location and inclination

of the keys, the height of the keyboard, etc., were selected.

Upon completing the course, all pupils converted to cybernetic code quite rapidly. The authors note with satisfaction that the children were reluctant to interrupt the exercises, which gave them great pleasure and increased their self-confidence and self-sufficiency.

Comparative numerical data on the speed of transmission achieved by one of the subjects are illustrative. After four years of practice prior to learning to type on the Cybertype, she had typed 5 words a minute (25 letters a minute) on an electric typewriter. After 11 hours of training on the Cybertype, her speed doubled, reaching 10 words a minute (50 letters a minute). Data are also cited on the speed of transmission for the adult blind man with both hands amputated in his operation of the Cybertype with semaphor control. He achieved astonishing results: at the end of his period of training, his transmission speed was 23 to 45 words a minute, i.e., 115 to 225 letters a minute. This is much faster than ordinary handwriting, and is on a par with the typing speed of a skilled typist.

* * *

In the USSR, the amount of work which has been done on keyboard systems for the transcription of alphabetic texts by anomalous children still lags perceptibly behind work carried out in the USA. In 1968-1968 [sic], V. A. Tsukerman, V. I. Gusakov, and the author proposed a six-key system for the illuminated transmission of letters by the deaf. (5) In this device, unlike the American ones, the transcription of letters was through elements which, when combined on a special illuminated panel, made it possible to produce the outlines of letters, figures, and punctuation marks. Instead of the simultaneous depression of only two keys, between one and five keys were depressed. In this case, the number of combinations of n keys where n = 6 amounted to $2^n - 1 = 2^6 - 1 = 63$. This is wholly sufficient for transmitting all letters, numbers, and

punctuation marks. The assimilation time for the six-key system proved close to the period indicated by the data of the American experimenters, and amounted to 10 to 12 hours of training for deaf schoolchildren between the ages of 14 and 15. Naturally, such a system cannot be used for people with amputated hands, since the depression of many keys requires the simultaneous work of three fingers on each hand.

On the basis of the six-key illuminated alphabet, a telephone was designed to transmit alphabetic texts over the Moscow telephone system. The first conversations between persons with hearing and deaf persons have been held. The speed of transmission was 70 letters a minute. There is reason to believe that the rate of transmission will increase as practical experience is increased. The layout and design of the six-key telephone are simpler than those of the American fourteen-key Cyberphone. This is determined by the volume of coded information to be transmitted over telephone lines. For the six elementary letters, this volume is several times less than for fourteen-key control.

The American system of cybernetic communications has certain advantages in enabling children with multiple defects to transmit alphabetic information. Notwithstanding the considerably smaller number of such children, compared with the number of children who are only deaf or only blind, the feasibility of devising such devices is without question.

Notes

1) Based on materials in a report by Haig Kafafian of the Cybernetics Research Institute, USA, Study of Machine Communications Systems for the Handicapped, Washington, D. C., Cybernetics Research Institute, August 1968.

2) H. S. Zim, Codes and Secret Writing, Washington, D. C., 1948 [retranslated]; J. R. Pierce, "Information Theory," Bell Laboratories Record, 1968 [retranslated].

3) This factor is essential not only for the code under investigation, but also for the rational arrangement of keys on

the keyboard of a standard typewriter. As shown by special studies conducted by A. Drovak, an American expert on engineering psychology, in typing with a conventional typewriter, the time spent in moving from one key to another determines the rate and speed of typing. The rhythm of typing, which, in his opinion, is also very important, is determined by the arrangement of keys in which the letters with the highest frequency are operated by the index fingers of both hands, which makes for concentration of motion. Drovak has expressed the opinion that the existing arrangement of the keys on standard typewriters does not correspond to scientifically substantiated conditions determining maximum typing speed. He has raised the question of revising the design of the standard keyboard.

4) In this connection, the authors refer to another type of coding — nirabkhaza — which was used in India in ancient times. It is a means of communicating with fingers but is more abstract than existing dactylology. Priests taking the vow of silence used it as a means of communication. Unlike European dactylology, consonants are indicated by various knuckles of the fingers, while vowels are indicated by the fingertips.

5) V. A. Tsukerman and I. V. Tsukerman, "Svetovaia azbuka dlia glukhikh i slabovidiayshchikh glukhikh," Defektologiia, 1970, No. 6

A FAMILY OF CYBERNETIC AIDS FOR THE HANDICAPPED

FOR RELEASE: 12:00 noon, Wednesday, January 29, 1975

Dateline: New York City

Results of a ten-year program of concentrated studies, by investigators at Cybernetics Research Institute (C/R/I), a non-profit organization in Washington, D. C., on communications and control systems for use by persons who are severely handicapped, were revealed today by Haig Kafafian at the 1975 Annual Meeting of the American Association for the Advancement of Science (AAAS) in New York City.

Kafafian, president and director of research of C/R/I, presented an invited paper, A Family of Cybernetic Aids for the Handicapped, which included a description of CYBERCOM*, a family of rehabilitational and educational aids for use by persons who have severe physical and/or neurological impairments. A research program supported by the Rehabilitation Services Administration of HEW for persons who are disabled was also reviewed. In addition, a program(1) which was supported by the Bureau of Education for the Handicapped (BEH), Office of Education, was covered.

The paper also dealt with the Cybertype*, a remote-control electric typewriter which allows a person with a handicap such as cerebral palsy(2) to type, using a lap-held 7-or 14-key portable keyboard, rather than the ordinary 50-key keyboard. Of the 200 children who participated

* Service Mark, Cyber Corp., Washington, D.C.

(1) Kafafian, Haig. Study of Man-Machine Communications Systems for the Handicapped. C/R/I Final Report, Volume III, 1973.

(2) This condition is manifested outwardly by muscular incoordination and speech impairment

in one of the earlier studies, 60% who previously could not write or type demonstrated that with the use of the new communication system they could effectively communicate and accomplish their school assignments in writing.

Other results of the studies revealed that of the remaining 40% of the students who were severely handicapped, all but about 5% could use another communications and control device, the Whisper-Type*, requiring only one key or switch which could be activated by voice, muscle, pneumatic, or pressure signals.

Kafafian stated that the results of the ten-year intensive program unequivocally demonstrated the feasibility of using man-machine systems. The cybernetic aids, he said, could be used not only in classrooms but also at rehabilitation and vocational training centers. The systems' value as a diagnostic tool particularly would assist evaluators and counselors in the assessment of a handicapped person's occupational capabilities. Kafafian stated that at least 2,000,000 of the nation's 7,000,000 children who are handicapped and quadriplegics, especially spinal-cord-injured veterans, would be the first to derive benefits from the advantages afforded by these cybernetic aids since federal legislation already has been structured to assist these segments of the handicapped population.

Kafafian also revealed and demonstrated for the first time publicly a converted voice-synthesizer, modified to operate from a single-

* Service Mark, Cyber Corp., Washington, D.C.

key interface. Its output is in the form of clearly understandable "speech" whose rate and pitch can be varied. Instead of typing letters, the user is taught to program the machine with phonemes, phrases and/or sentences which are retrievable in the form of entire words, phrases or sentences. In addition, the device's capability permits storage of complete messages which can be selectively retrieved.

Kafafian also explained the advantages of HAIBRL, a two-dot unambiguous tactile writing system designed for use by blind persons who do not use braille. About 90% of the blind population, Kafafian noted, cannot use braille effectively because it is difficult to learn and complex. The fact that braille uses an ambiguous coding in which 50% of its patterns have multiple meanings further reduces the user's reading speed. Another cybernetic aid described was a device which permits a person who is deaf or speech-impaired to use a telephone.

Kafafian said that school administrators, educators, and parents need no longer ask in vain the question: "Will advancements in science provide us with practical means for helping our children who are multiply handicapped?" Kafafian stated emphatically, "The new technology is now at hand and has been and will continue to be successfully demonstrated through use not only of man-machine systems but of newly developed programmatic instructional materials for use by special educators and rehabilitation personnel who are pioneering in these advancements."

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A new concept* under study at the Institute could result in a device which may reduce traffic deaths and injuries and at the same time afford blind persons safer mobility through the system's capability of locating, identifying, and communicating with persons who are blind or deaf/blind.

Kafafian predicted that new scientific knowledge, if permitted free pursuit and exploration, could aid the ever increasing number of United States citizens who are identified as being either physically and/or neurologically handicapped--a number now estimated at approximately 42-million persons.(3) With advances in medical and health care delivery systems we can expect to see more severely disabled and aged persons living longer. Kafafian also ventured that by the year 2000 A.D., a 25-year-old person's chance of employment--even though she or he is congenitally brain damaged--would be no different than that of a non-handicapped person of the same age, assuming a comparable cognitive ability and educational background. One example is in the field of computer sciences where emphasis is on mental skills rather than on physical capability.

"The greatest obstacle right now," Kafafian explained, "is social attitude towards persons who are disabled. This attitude is reflected in the policies of government and especially of industry which govern the hiring of the handicapped."

"The responsibility for aiding persons who are severely disabled,"

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(3) *Senator Robert Dole. Congressional Record, No. 51, Washington, D.C. April 14, 1971.*

* *Cybernetics Collision Avoidance, Identification, and Control Systems for Vehicles, Pedestrians, and Persons who are Disabled. Private Communication, Raig Kafafian to Julian Bigelow, January 1975.*

Kafafian continued, "no longer rests entirely on the compassion and skill of physicians, parents, scientists, and educators. All of society is responsible for the education and rehabilitation of its citizens who are handicapped. Dedicated legislators and statespersons charged with shaping public policy, and industry executives who are expanding their companies' social responsibilities, together with underwriters, must endorse these efforts. Further, the value of strong union support cannot be underestimated."

Kafafian concluded by reiterating the particularly pressing and critical problems which now confront scientists who seek solutions for that segment of the population which is deaf/blind. "We have hope," he said, "that in the near future present educational and rehabilitational systems will better utilize man-machine systems and their languages, and that new coding techniques compatible with the remaining sensory, motor, and cognitive abilities of the person who is severely disabled will be discovered. But, we can launch these achievements into practical reality only by overcoming prejudicial attitudes towards persons who are handicapped and by recognizing their critical need for education, rehabilitation, and employment."

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Appendix D

WORK PLAN
on
DEAF-BLIND COMMUNICATIONS AND CONTROL SYSTEMS (DEBLICOM)
FOR PERIOD: 1 SEPT.1975 to 31 AUG. 1976

REF: GRANT NO. 23-P-57488/3-03, REHABILITATION SERVICES ADMINISTRATION OFFICE OF HUMAN DEVELOPMENT, DEPARTMENT OF HEALTH, EDUCATION AND WELFARE

I. INTRODUCTION - The work plan for the subject grant is divided into four main categories or areas of effort and these in turn are subdivided into a total of 22 tasks. The four work areas are:

1). DEBLICOM Harness and Code for the Deaf-Blind

2). Mobility Aids for the Deaf-Blind

3). Synthesized Speech for the Deaf-Blind

4). Project Reports

A description of each of the 22 tasks in these four work areas is provided below. The Time Chart, Figure 1, shows the proposed schedule for the forthcoming 12 month grant period.

II. TASK DESCRIPTIONS - DEBLICOM HARNESS AND CODE FOR THE DEAF-BLIND

Task 1. Design, Engineering, Fabrication and Procurement of Stimulators - On the basis of information derived from the literature search carried out during the past grant period a variety of cutaneous stimulators will be obtained where available or designed, engineered and fabricated in order to investigate their utility as effective transducers in the DEBLICOM harness.

Task 2 Design, Engineering and Fabrication of Drivers and Controllers - Appropriate drivers and controllers will be designed, engineered and fabricated for operation of the stimulators from Task 1 for use in the tests of Task 3.

Task 3. Test Cutaneous Stimulators - The stimulators of Task 1 will be tested initially using non-disabled subjects having normal hearing, sight and speech capabilities to determine the most desirable transducer elements for the system. They will be tested for such characteristics as useful range of exitation, consistency of sensation over time and body loci, power requirements, and ease of control, among others.

Task 4. Design, Engineering and Fabrication of Harnesses and Controls - Based on the preliminary results of the tests of Task 8. (See Task 7 below), harnesses configured with a pattern of cutaneous stimulators will be designed, engineered and fabricated for DEBLICOM testing. Controllers and logic circuit engineering and fabrication for coupling the harnesses to the systems interfaces and their subsystems will also be part of Task 4.

Task 5. Selection of Deaf-Blind Subjects - C/R/I field centers and other centers working with the deaf-blind will be asked to provide information on persons who are deaf-blind who are potential candidates for training and testing with DEBLICOM. Candidates selected will consist of a heterogeneous group of eight persons. Subjects will be matched for developmental level.

Task 6. Test Design for Deaf-Blind Subjects - Training and test procedures to be employed with DEBLICOM will be designed in detail. The operant conditioning procedures (deter-

mination of reinforcers, response strenghtening, discrimination training, response differentation) will be specified following the procedures delineated in C/R/I's DEBLICOM Progress Report dated August, 1975, for the past grant period. Performance measures will be selected along with statistical tests for their outcome.

Task 7. Selection of Cutaneous Stimulators - The results of the cutaneous stimulator tests of Task 3 will be evaluated. One or more stimulators will be selected for use in the system on the basis of the findings of these evaluations. The selection of stimulators follows the commencement of work on the harnesses.

Task 8. Test Designs for Systematic Codes - Performance measures for the system will be selected in this task. These will include both measures of acquisition rates and final performance levels. Both message rates and error rates will be measured. In this task, candidates from centers will be selected for subjects to be studied for data collection.

Task 9. Test Non-Redundant Code, Normals - Four normal subjects will be trained on the code for forty hours using position coding alone (non-redundant coding). The measures decided upon in Task 8 will be employed.

Task 10. Test Redundant Code, Normals - Four normal subjects will be trained on the redundant code (See C/R/I's Interim Progress Report) which uses duration, intensity and attack

rate; as well as position. They too will be trained for forty hours. Again, the measures decided upon in Task 8 will be employed.

Task 11. Selection of Code - Statisical tests will be used to measure the statistical significance, if any, between performance on the redundant code and performance on the non-redundant code. The results of these will determine the code or codes to be selected.

Task 12. Train Instructors, Train and Test Deaf-Blind Subjects - Training of instructors and training of deaf-blind subjects selected in Task 5 will be undertken in this task. Train- will involve the procedures developed in Task 6. and the code selected in Task 11. This task will extend into Phase III of the program.

III. TASK DESCRIPTIONS - MOBILITY AIDS FOR THE DEAF-BLIND

Task 13. Selection of Other Assistive Aids to Integrate with DEBLICOM - Those assistive aids applicable and useful to this segment of the disabled population and which are considered candidates for integration into DEBLICOM will be selected in this task.

Task 14. Design, Engineering and Fabrication of Couplers and Controls - The mobility aids selected in Task 13 will be obtained, modified as required and integrated into the system in preparation for testing during the third phase of the research. Required couplers and controls for the system integration of these aids will be designed, engineered and fabricated under this task.

IV. TASK DESCRIPTIONS - SYNTHESIZED SPEECH FOR THE DEAF-BLIND

Task 15. Selection of Phrases and Messages - Information will be collected from C/R/I field centers and other centers working with the deaf-blind on the phrases and messages which are considered to be critically important for this segment of the disabled population. We will use both an open information request, to prevent the biasing of responses by the suggestions of others; and a multiple-choice form for those who prefer not to use the open form. The results will be tabulated and reduced to determine the basic set of phrases and messages which will be used in the voice synthesis subsystem of DEBLCIOM.

Task 16. Selection of Deaf-Blind Subjects - The sources contacted during Task 5 will be asked to provide information on persons who are deaf-blind who are potential candidates for testing of the voice synthesis subsystem. Available subjects will be screened and a group selected for the tests.

Task 17. Phonemic Programming - The basic set of phrases and messages will be translated into phonemic notation for use in the voice synthesis subsystem.

Task 18. Read-Only-Memories (ROM) Programming - The phonemic notation of Task 17 will be translated into machine language for the voice synthesizer of the subsystem. Read-Only-Memories will then be programmed for storage of the basic set.

Task 19. Design, Engineering and Fabrication of Couplers - Couplers will be designed, engineered and fabricated for integrating the voice synthesis subsystem into DEBLICOM so that a

DOCUMENT RESUME

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ABSTRACT

The guide for nurses consists of 10 papers on identification and management of selected developmental disabilities. Included are the following titles: "The Importance of Early Mothering" (R. Benfield); "Infant Stimulation" (J. Arnold); "Failure to Thrive" (M. Haynes); "The Neurological Evaluation of Infants and Young Children" (R. Williams); "Genetic Aspects of Mental Retardation" (R. Summitt); "Inborn Errors of Metabolism and Mental Retardation" (G. Billmeier); "Community Nutrition" (P. Zee); "Dietary Treatment of Phenylketonuria" (M. Smith); "Behavior Modification: Approaches to Teaching Feeding and Toileting Skills to Handicapped Children" (V. Stimbert); and "Developmental Screening" (F. Russell). (LS)

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A Guide for Nurses

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Identification and Management of Selected Developmental Disabilities:

A Guide for Nurses

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Foreword

This booklet is intended for people who have an interest in the care of children who are mentally retarded and/or developmentally disabled. It contains selected reports by health professionals representing several disciplines, which were presented at the annual workshops for nurses conducted by the University of Tennessee Child Development Center in Memphis between 1970 and 1973. This training effort was funded through Maternal and Child Health Project Grant No. 900. The articles in this booklet have been adapted for publication.

The Child Development Center began as a service program for the retarded in 1957 and began the clinical training of students in 1966. The training effort is mainly devoted to graduate and post-graduate students who are seeking specialization and those working in the field who want to review current developments.

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The Importance of Early Mothering

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Every health care professional appreciates the importance of early mothering. The effects of maternal deprivation are well documented and have been witnessed all too often. The difficult task of assessing mothering and intervening when appropriate usually becomes the responsibility of the nurse.

Mothering is something that little girls probably begin to learn with their first dolls. However, the attitude of the mother toward her infant can probably best be seen forming during her pregnancy. Pregnancy is a period of crisis, involving profound endocrine and general somatic as well as psychological changes. Pregnancy is a significant turning point in the life of a woman. The mastery of this phase depends on the outcome of this crisis, the solution and maturational reorganization of this disequilibrium.

Hormonal and metabolic changes bring increases in vital energy, new feelings, a revival of old fears and conflicts, and a tendency toward introspection. The emotional changes revive the woman's early childhood thoughts about pregnancy. Anxiety which was formerly mastered becomes reactivated; it brings tension and emotional and physical discomfort. New emotional needs are created and they hunger for gratification. The pregnant woman's interest becomes centered on herself, her body, her feelings and her unborn child. She may become withdrawn, contemplative and anxious. Dependency longings which formerly were handled are revived. These feelings, according to research, cross cultures and can be seen to some degree in every pregnant woman. It is most important to recognize that unfulfilled needs prevent the full development of motherliness, which is important both to the mother and the child.

A pregnancy frought with psychological suffering cannot help but influence the mother's attitudes and feelings toward her unborn child. It can influence the kind of relationship she will be able to establish with her infant in the crucial newborn period. When the mother sees her child as the cause of her discomfort, feelings of resentment tend to occur.

The antepartal time is one opportunity the nurse has to influence the future relationship between the mother and infant. Each nurse must ask: What can be done to promote a positive relationship? How can one intervene into the mother's needs during pregnancy?

The new mother, having gone through labor and delivery, anxiously awaits a glimpse of her infant. When she finally has her baby, he seems so small; she's afraid she might hurt him. Initially, she just looks at that little bundle and then fingers his face. At first, she holds him at a distance and gradually works toward enfolding him in her arms. Every mother seems to go through this process of working near to her infant. Some do it quickly, some more slowly.

The mother has a need to continue the symbiotic relationship with her baby. She needs support and the attention and interest of others who are also proud of her accomplishment. She needs freedom from frustration and anxiety so that she may experience pleasure in her role as mother. Meeting the physical and emotional needs of the mother gives her time and energy to cater to her infant's needs.

Whose nursing responsibility will this be? Is it the nurse in labor and delivery; is it the postpartum nurse; the public health nurse at the postpartum visit? Or is it a joint responsibility? It seems that not only is this a joint nursing responsibility, but with the present routine of delivery today and home tomorrow, the public health nurse may need to assist the entire family antepartally to help this new or even experienced mother.

A study was done with 50 middle class primiparous mothers several years ago. The mothers were visited during their hospital stay and any questions they had were answered. Then, operating on a principle of crisis intervention, a visit was made 24-28 hours after they arrived home. The study revealed the following. First, the number of questions the mothers asked when they were home increased approximately 25 times over those they asked during the hospital visit.

This indicated that unless we attempt to acquaint the mothers with their infants to a greater degree while in the hospital, the responsibility for responding to their insecurities remains with the nurse who has contact with the mothers after their babies are home.

The second factor of interest was the type of questions the mothers asked. They centered around stools, feedings, cord care and dress, and warmth needs of the infant. These questions are basic information a new mother needs and must have in order to feel adequate.

Mothers react to their new responsibilities in different ways. Some women find that being a mother is the most satisfying and fulfilling experience they have ever had. Others feel fatigued, overburdened and resentful. Becoming a mother may change their life style from one which was free and enjoyable to one which is full of demands and very restricted.

Cultural factors may affect the mother's feelings about motherhood. Within the new mother are the standards, goals and ideals which she has assimilated from her family background and society. She may attempt to follow the standards of her culture and experience great frustration; or, she may reject them and attempt to formulate new standards according to her own needs. Regardless, social pressure will force her to feel she should strive to attain the standards of her culture. This can be seen in the hippie commune. On one hand, these new mothers have family background pressuring them toward conventional middle class standards. On the other hand, their new beliefs and communal pressure are pushing them toward a new standard. As Florence Blake has pointed out, "A mother needs to feel the nurses' acceptance of natural feelings through her response to the conflicts and the stresses she knows are characteristic during the period the family is becoming adjusted to a new way of life."

The following case presentations offer examples of intervention into a disturbed mother-child relationship. Chris was being breast fed. At the 3-month visit it was noted that he was falling off the growth curve. In the diet history the mother reported a laissez-faire method of feeding. Sometimes she fed him for 15 minutes, sometimes for 45, depending on how she felt. She expressed concern that Chris had become a temperamental infant, crying frequently with seemingly great anger. The growth curve was explained to her and the need for more food discussed. It was also explained that Chris needed to be watched closely to make sure there was not a physical reason for his lack of weight gain. Needless to say, this mother went home very much aghast. She expressed difficulty in returning for an appointment in one week, but with some encouragement she did come. Fortunately, the baby had gained weight and the mother could be given a great deal of support. On the next visit the baby had gained again, and it was possible to discuss with this mother her feelings when told she was not feeding her baby enough. She explained that she felt horrible and verbalized the difficulties of being a new mother. Chris is going on 3 now and shows no signs of a child that is failing to thrive. An initial period of time for mother and nurse to establish a relationship is important. The nurse must be supportive, encourage honesty and recognize the difficulty in suddenly being on duty 24 hours a day as a mother. Without this initial relationship, the mother is not likely to provide the clues to her problem and may try to hide her difficulties adjusting to a new life style.

Certainly there are many cases which do not turn out so favorably. Jessie was first seen when he was 6 months old. Jessie's mother is mentally retarded. Jessie was below the 3 percentile level on the growth curve. While taking his diet history, it was noted that Jessie was on table food and one 4-ounce bottle of diluted formula each day. According to the Denver Developmental Screening Tool, Jessie was doing all the tasks within the realm of a 6 month old. His mother was praised for her efforts to provide him with stimulation. She was encouraged to give Jessie one additional bottle each day and to increase the strength of the formula. It was hoped that the mother could handle this initial step. She returned in 1 week; Jessie had gained weight and she had followed the nurse's instructions. It was decided to try an additional step and she was asked to increase each bottle to 6 ounces. Jessie and his mother never returned to the clinic again.

There are a number of nursing projects that have attempted to prevent and/or deal with maternal deprivation. In one such project, the public health nurses visit each mother from their district who is on the postpartum floor of the hospital. They answer any questions the mother has and obtain information such as whether or not a support person will assist her during the first few days at home. The mother's ability to care for her infant is assessed and home visits are planned for those who seem to be at greater risk. A clinic visit is scheduled during the baby's first 2 weeks of life as experience has shown that, after a month to 6 weeks, the mother will find some solution to this crisis situation and the professional is not able to interevene as readily.

In another project, the nurses identify high risk antepartal patients. High risk is defined as a client who seems at greater risk in establishing a healthy mother-child relationship, such as the extremely young mother, the mother who has attempted abortion, or who verbalizes not wanting this infant. These mothers receive frequent home visits from nurses who assist them in working through their feelings.

Each nurse must consider her work situation and the needs of her clients. Perhaps classes could be offered on the postpartum floor, jointly sponsored between hospital and community nurses. Perhaps bench conferences could be held in the antepartal clinic waiting room; or, block parties

held with the experienced mothers providing new mothers with advice. The nurse must take responsibility for considering new and creative means of solving and preventing maternal deprivation.

As the child grows older, the nurse must continue to consider the importance of mothering. Some of the cardinal rules to bear in mind include recognizing that no one has identified one right way to mother. The method which the nurse may use with her own child might be inappropriate for another mother and child. The questions that have to be answered are: Is the mother comfortable and thriving? Is the child comfortable and thriving? If the responses are yes, they have a good mother-child relationship; although, their cultural or social dictates may be foreign from the nurse's.

It is the nurse's responsibility to foster a relationship that is comfortable for that mother and that child. How can it be done? The first effort must be to foster a trust relationship with the mother, so that she can be honest with the nurse. It is necessary to utilize a questioning technique that provides the mother an opportunity to talk openly. Open ended questions with responses accepted is one essential technique. It is so easy to give a mother the answer the nurse wants to hear and ask her to respond yes to that question. During the first clinic visit, the nurse should ask if the mother has had a chance to get away. She may have had no desire to leave her baby yet, but it's important for her to get the message that the nurse knows it's a lot of work to care for an infant. It's acceptable to want to get away and important to meet her individual needs too. Then when she is ready to get away, she won't be as likely to feel guilty.

Another cardinal rule is to positively reinforce the mother for the job she's doing. No matter how poor the mothering technique is, there is always some aspect of the care that can be praised. Even with a battered child, the parents can be supported for the fact that they were concerned and brought the child to the clinic. The last cardinal rule is to attempt to demonstrate some techniques of positive mothering while you are inspecting the child.

What does one do when the mother seems incapable of mothering and her infant is not thriving? One group of nurses decided that in order to break the cycle of maternal deprivation, the focus would have to be on the mother. In response, a group was initiated entitled "Mother's Day Out." The group was formed to give the mother a chance to get away for an hour, recognizing she had a great deal of responsibility. The clinic is used on an afternoon that is unscheduled for clients. The waiting room is set up with decorations; games are selected; quarters given for prizes and refreshments served. The mothers are encouraged to participate in planning the activities. Staff members pick up the mothers and take them home.

At the same time, an infant stimulation program is conducted in the back half of the clinic. The children are tested for developmental lag using the Denver Developmental Screening Test. An attempt is made to increase the child's skill in the area where the lag is greatest. The facilities and toys are directed at gross motor, fine motor, language and personal-social development. The hope is to eventually improve the child's developmental level through better mothering. Developmental advances on the part of the children and changes in the attitude of the mothers have been noted.

These nursing projects are not appropriate in every clinic setting. However, they will provide the nurse with some clues as to how she might meet her client's needs and stimulate her own creative solutions.

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Infant Stimulation

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Introduction

In the past, many researchers have believed that the infant was too busy eating and sleeping to do much in the way of learning. Many thought that his development resulted almost entirely from physical maturation. (1) Some authors have further described the infant as a decorticate organism, incapable of sensory experiences and limited to reflex reactions. (2) In his description of the birth experience, in 1890, William James said, "The baby, assailed by eyes, ears, nose, skin, and entrails at once, feels it all as one great blooming, buzzing confusion." (3)

It is certainly no wonder, then, that research related to the infant is only recently coming to the forefront in child development studies. Although there is still much dispute about infant learning, most researchers do agree that the infant is "a person in action, unless he is retarded or seriously disturbed." (4) Examinations of the infant's behavior show that it is flexible from the beginning. Although he has few controls at first, the infant can devise strategies for working within his limitations.

There is much evidence now, on both well-stimulated and deprived children, which points toward the extreme importance of various kinds of experiences during the infancy period. In fact, some researchers maintain that there is a critical period of time in which learning of a specific nature must take place, if it is to occur at all. (5) They see normal development as involving the acquisition of many sequentially dependent responses. Failure to learn any particular segment prevents the acquiring of subsequent links in the chain. (6) This school of thought holds that stimulation and therapeutic intervention, if not begun before the critical time period, will not benefit the child. Studies in this area have involved animals, not humans, and are somewhat contradictory. Scott, Hess, and others suggest that, in certain lower animals, there exist functions capable of being learned only during circumscribed periods of development. (7)(8) In other experiments, with various laboratory animals, Levine, Denenberg, and Harlow concluded that close physical contact and stimulation are essential for adequate physiological, emotional, and adaptive development. (9)(10)(11)

Some of the research has also shown that more than two-thirds of the children labelled as "slow learners" and "school failures" are retarded because of environmental deprivation prior to coming to school. (12) Certainly, Head Start was one move toward combatting this problem, but is becoming increasingly certain that efforts at education must occur even earlier, as early as the period of infancy.

Some current research has been done with various infant stimulation programs carried out either in special day care settings or in the home. Although these experiments have demonstrated that early education can be valuable, there has not yet been a systematic evaluation of the effectiveness of different approaches to stimulating the infant. More needs to be known about when to intervene and what experiences are most valuable at a particular time. (13)

The Nurse's Role in Infant Stimulation

The mother's problem, when she has a very young child, becomes one of knowing what to do after she had bathed, clothed and fed her baby. How can she create a suitable environment not confined to the cradle or crib?

This is where the public health nurse can be important. During the first year of life, she may see the child more often than other health personnel, and she is often at an advantage of observing, not only the child and mother themselves, but also their home environment. She can assess the the need for assistance in planning activities for infant stimulation and help the mother to carry through on these activities.

The extent of assistance a mother needs depends on many factors: her own knowledge of normal growth and development; whether the infant's chronological age is the same as his developmental age; whether he is an only child; a high-risk child; etc. Certainly, over-stimulation can be as dangerous as under-

stimulation and must be taken into consideration by the nurse.

Infant stimulation, then, can be defined as an individualized program of learning geared toward each particular child's physical and emotional needs. This planned program is generally carried out by the mother at home, but with specific guidance from trained personnel, and is begun in infancy, prior to planned preschool programs.

The Importance of Play

Prior to helping the mother with infant stimulation, the nurse must be cognizant of two factors: 1) the developmental level of the child, which she should be able to assess; 2) the interplay between development and a child's play. A child learns what he knows through the mechanism of play.

Play has been defined as "a function of the ego, an attempt to synchronize the bodily and social processes with the self . . . when man plays, he intermingles with things and people in a similarly uninvolved and light fashion." (14) Play is also seen as a self-rewarding activity through which the child is encouraged to learn by the very enjoyment of play. (15) Through play, the child has a method of exploring his world, of testing new ideas and concepts, of venturing into the unknown, of testing reality and his own powers. "Play permits the child to respond to challenge by influencing his environment, initiating action, and observing results." (16) The child views play as work, art, thought, and relaxation. Play is his preparation for living, for understanding the daily life around him, as well as his own feelings. (17)

From the above, it can be seen that play can be considered separately but not separated from the child's development. "Play is the occasion for individual development, cultural patterning and the beginning of competence in many activities." (15) It provides the major opportunity for learning to learn and allows the child continually to practice and develop proficiency in a variety of actions. (15) Although play can be used for diagnosis, therapy, education, and studying children and their reactions, it remains mainly their developmental tool to conquer experiences and developmental tasks facing them. (18) Play is a crucial part of the child's development and, as one author states, "the great bridge over which children must pass in order to grow up." (19)

A child's play begins with and centers on his own body and actually starts before we even notice it as play. It consists of investigation through repetition of sensual perceptions, kinesthetic sensations, and perhaps of socialization. It progresses in a definite sequence, from simple to complex activities, with social, motor, verbal, and intellectual involvement. (14)

Motor development, then, is concurrent with play. At the same time that the child is developing posture and locomotion, he is simultaneously bringing his eyes, arms, and hands under his control. "The sequence of development is looking, reaching, contacting, grasping, handling, and finally exploitation of objects." (20)

Looking comprises the infant's first reaching action. The child's eye movements gradually become better coordinated, so he is able to follow an object to midline and then later to follow an object 180 degrees. Eventually, he begins to really look at individual objects, preferring large and brightly colored ones. (20)

At about this time, the arms and hands begin playing a part in the infant's investigation of his environment. Although he starts with a total body response to an object, lunging for it; he later manages a two-hand grasp, using a whole-hand approach. At this time, he keeps his hands close to his chest and readily puts objects into his mouth, for further exploration. Eventually, the infant begins to grasp with one hand rather than both hands. He reaches for an object as soon as he sees it, mouths it, looks at it, shakes it, bangs it, and finally releases it. At this time, he uses his whole hand to grasp and cannot yet release voluntarily. (20)

Gradually, the infant develops a well-coordinated hand as well as sharp and accurate vision. He has a definite preference for one hand and has good prehensile grip. He can also release voluntarily. By this time, too, voluntary control has extended to the peripheral body areas: the finger tip, tongue tip, and toes. The child's interest begins to move from big objects to little ones, and he begins to explore three-dimensional objects with his outstretched finger. He is also beginning to talk more about what he sees and touches. He is utilizing in play all his voluntary apparatus to take in and assimilate sensory experiences. (20) The child has learned the basic important motor patterns and, as his body continues to become better organized, he can begin to prepare himself for the later development of more complex functional skills.

By picking the right toy, "the right muscles are strengthened, attention span is increased, coordination is improved, skills can be taught, social adjustment gained and, most of all, the child is provided with what the toy was originally designed for—fun." (21)

In working with the child it is very important to see that he has within his reach, if he will make the attempt, toys that stimulate him to continued activity and development.

Infant Stimulation in the First Year of Life

Young infants can often be observed within the first few days of life, staring and attending to things in their environment and, indeed, some of the earliest studies of infants have been done in the area of visual perception. The question now is not *whether* an infant sees, but *what* an infant sees. (22) Frantz did a study of 18 infants under 5 days of age, presenting them with various objects and measuring the degree of visual attentiveness. He found that 11 infants regarded a picture of a face longest; 5 regarded a bull's-eye pattern; 2 looked at newsprint; and none looked at

white, fluorescent yellow or red objects. Newborns, then, not only prefer patterns over color, but they also have definite preferences in patterns.

In the area of visual scanning behavior, a study done by Korner and Grobstein revealed that, of 12 neonates, 90 percent had their eyes open when held, and only 25 percent, when left alone or in a sitting position. It seems that visual orientation is facilitated even more by handling. (23) Murphy also found that infants are not relaxed until held in a position from which they can see around.

There is also the "response decrement" idea, which points out that children look less and less at patterns they are repeatedly exposed to and more and more at novel ones. This seems to have many implications regarding the importance of variation of visual stimuli. (24)

A final study involving vision was conducted by Gibson and Walk, who raised two groups of litter-mate rats under the same circumstances, except that one group had metal cut-outs of a triangle and a circle on the wall of the cage. No attention was drawn to these figures. When the rats were later tested in discrimination of geometric forms, the group that had been raised in the cage with the cut-outs learned faster and made fewer errors than the other group. (25)

Many other studies have been done which show that the young organism can also discriminate among various stimuli. Lipsitt's studies, for instance, showed that neonates could distinguish between two olfactory stimuli. (26) All of the above findings indicate that even immature organisms share many traits with mature organisms.

In studies examining infants several months old, further information was gained. Again, in the area of visual perception, many studies involving the presentation of schematic and scrambled pictures of faces, showed that the schematic face was preferred only in infants between 2 and 3 months of age. (22) However, a study by Kagan demonstrated that, even though 4-month-old infants had the same fixation times to regular and rearranged faces, smiling was more frequent with the regular face. (27) Further studies by Fantz pointed to the fact that children over 2 months of age prefer solid over flat objects.

The baby learns by listening as well as by visual-motor activities. In the area of auditory stimulation, one author conditioned infants as young as 2 to 6 months to turn their heads to the right at the sound of a tone but not a buzzer, and then taught them to do the reverse. According to the author, this lends some credibility to the proposal that the infant is not only learning but also may be remarkably sensitive to environmental events. (28) Another author relates a story of a 4-month-old baby who learned to recognize the sound of her father's footsteps and bounced in her carriage when she heard him coming. (1)

As the child's language develops and he begins to babble, it becomes possibly even more important for the mother to talk with her baby. Studies carried out by the Menninger Foundation revealed a positive correlation between a mother's talking and a child's vocalization, and also between the child's vocalization and his later IQ. (29)

Many other studies have been done and are currently being done in the area of infant stimulation. Regardless of the fact that many authors disagree on specific findings, one fact does emerge which most researchers would agree with: the infant is an active, growing organism, aware of and responsive to its environment. It seems that this is enough reason for us, as nurses, to encourage parents to stimulate their children.

Listed below is a guide for play that may be helpful in working with mothers and their infants. The age range, developmental description and appropriate materials and activities for the first year of life are included.

Play and the Infant

Age	Developmental Description	Appropriate Materials and Activities
BIRTH THROUGH 2 MONTHS	1. Enjoys sensation of various kinds.	
	—visual perception—learning what movements are and how to focus.	make the crib area interesting with colorful cloth, pictures, mirror, etc.; hang a mobile level with the crib's rails and in line with the baby's eyes and gaze—change sides every other day.
	—auditory stimulation	sing and talk to the baby. Have musical toy or use radio.
	—touch	hold, cuddle, and rock baby.
	2. Enjoys movement.	change baby's position frequently to allow him freedom of movement. Move child around house into various rooms.
	3. Follows objects to midline.	shake brightly colored yarn ball 6-12" in front of child and encourage following.

Play and the Infant—continued

Age	Developmental Description	Appropriate Materials and Activities
3 AND 4 MONTHS	Beginning to find out about himself and the fact that he is different from objects.	
	1. *Discovering his body* —feet, hands, and eyes need to learn to work together.	tie bells on baby's booties or put them on his ankles with elastic which is not too tight. Help him learn to kick his mobile to make it move.
	2. *Discovering objects* —beginning to develop finger flexibilities and dexterities and learning to visually grasp objects.	wave rattle in front of baby to get him to follow and later reach for it.
	—more active reaching coming into play.	use cradle gyms.
	—using a bidextrous approach to toys, both hands moving in unison.	if toy goes out of reach, place it on his chest so he can use his hands to retrieve it.
	—mouthing objects.	use safe rattles, squeeze toys.
	3. Continue with auditory and tactile stimulation.	
5 AND 6 MONTHS	Increased ability to spot and reach objects in space and to make things happen to objects.	
	1. *Motor Activities* —using to two-handed grasp.	attach elastic to a spool and dangle in front of baby; tug at it when he grasps it, and pull gently.
	—beginning to release objects.	place objects in highchair; as he throws them to the floor, say "there it goes," "all gone," and "here it is."
	—recovering toys within his reach.	put the baby in various positions and put attractive toys within his reach.
	—sitting supported.	place vacuum-base toys on highchair tray or playpen or cribside. Use yielding (not too firmly stuffed) nylons as stuffing for toweling covered toys; use no buttons, eyes, or small parts.
	2. *Sensory Activities* —visual perception—beginning experience in visual size and visual distance.	place baby on tummy; move toward and away from baby while talking to him, to keep his attention.
	—auditory and language stimulation—localizes sound correctly and has a beginning fascination with appearance and disappearance; babbling.	play hide-and-seek—call the child's name and then show yourself to help him learn to identify the source of sound. Ring a bell behind the baby so he turns to the sound. Imitate his speech sounds.
	—tacticle stimulation—needs to explore and experience different textures and surfaces.	make texture balls of many different materials.

Play and the Infant—continued

Age	Developmental Description	Appropriate Materials and Activities
7 AND 8 MONTHS	1. *Motor Activities* —needs to move around a lot to see things from every side; needs to look at and touch everything he can reach and he will try to reach almost everything he can see.—holding two objects at once; beginning to bang them together. —grasping with one hand; bidexterity giving way to permanent pattern of unidexterity.	make and give the baby yarn and string pompoms to feel and throw. Arrange a pot and pan corner cupboard which he can reach and open himself; put tissue paper, clean rags, and pans in it. Give him lids and other non-breakable household objects to bang together.
	2. *Social Interaction* —becoming shy with strangers.	mother should stay in sight in new situation, so baby learns that strangeness isn't threatening.
	—beginning social response to mirror image.	place baby on your lap and have him point at himself in the mirror when you ask him where he is; say his name.
	3. *Sensory Activities* —tactile stimulation.	continue to give baby objects of various sizes, forms, and properties and talk with him about these. Encourage water play; use sponges and floating toys.
	4. Beginning to learn that things exist even when he cannot see them.	hide one of the baby's favorite toys partially under a blanket; ask him to find the toy and show him how, if he has difficulty; eventually hide the whole toy and have him find it. Place one of his favorite toys in a box or other container that is easy to open; ask him to find the toy.
9 THROUGH 12 MONTHS	1. *Motor Activities* —interest is shifting from big to little objects, with the development of good prehensile grip and the use of the index finger to poke and pry.	provide covered storage dishes with surprises inside. Decorate trash basket of discarded envelopes, letters, and pamphlets. Use puzzle with only two figures (lifted out by tiny knobs).
	—beginning to release voluntarily (greater difficulty with small objects).	use many "fill n' dump" activities. Starting with a large container the child places good-sized objects into and eventually providing smaller containers with slits in the top, to put objects such as poker chips into. (Other examples: place clothes pins around edge of baking pan and have child remove and replace; put wooden milk bottles in small carrier).
	—gross motor—baby needs to crawl, wriggle, and creep.	let him get stuck under furniture; show him how to get out but *don't* pull him out.
	2. *Sensory Activities* —encourage language interactions.	look at pictures with child, naming objects; talk about baby's activities. Utilizing face to face rhythm games and finger play (This Little Pig, Pat-a-cake, Row, Row, Row Your Boat).
	—elaborate on self-concept.	teach him names of body parts, using the mirror.

Play and the Infant—continued

Age	Developmental Description	Appropriate Materials and Activities
	3. Continue to teach permanence of object concept and knowledge of the fact that objects have insides and outsides.	play peek-a-boo. Play searching games (such as hide a toy in a box inside a box).
	4. Develop a recognition of shapes.	use graduated nesting toys. Design a shape-sorting box, with holes of different sizes in the cover; drop appropriate objects in the holes.

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Failure To Thrive

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Underlying Viewpoints

The studies of Dr. John Bowlby during World War II regarding orphaned children who failed to thrive have become a guideline for more specific investigations. Dr. Bowlby's premise was that love is a necessary ingredient in an individual's ability to grow. (1) Furthermore, the infant is uniquely dependent on his environment for the means of his life and well-being, and is constantly at risk of failure to thrive. Beginning studies by Dr. Bowlby in 1948 and Dr. Ainsworth in the early 1950's were based on the idea of love being given by the natural parent: namely, the mother. (1)(2) As studies by these investigators and others progressed, they found that a parent substitute or a "caring person" in the institutional setting could provide the necessary love needed for growth.

In 1950, Dr. Bowlby discovered that several countries in Europe—France, the Netherlands, Sweden, Switzerland, and the United Kingdom—and the United States of America had been studying this area of non-thriving infants and young children. Dr. Bowlby stated, "What each individual piece of work (in the different countries) lacks [in] thoroughness, scientific reliability, or precision is largely made good by the agreement of the whole. To the extent to which these studies, undertaken by people of many nations, varied training, and, as often as not, ignorant of each other's conclusions, confirm and support each other is impressive."

Dr. Erik Erikson's theory of "basic trust" lends emphasis to the viewpoint that from early infancy basic trust is needed in the formation of a healthy personality. (3) The mother, or an important other person, gives gratification to basic needs which is crucial to the development of the infant's whole personality.

During the two decades following Dr. Bowlby's studies, Dr. Mary Ainsworth worked to substantiate his findings with uninstitutionalized children. Her studies reaffirmed his findings in the area of failure to thrive.

Selected Readings from Studies

During 1958 to 1972, studies on failure to thrive were begun by physicians, social workers, nurses, sociologists, psychologists, and others in various parts of the United States. It is noteworthy that during this 14-year period many agreements regarding environmental characteristics, characteristics of mothers and families, and characteristics of babies who failed to thrive had been reached. However, like the first studies which were done in different countries, there was little chance to share results.

An attempt has been made to highlight those studies which pertain to babies and children who failed to thrive in the absence of known metabolic or other organic dysfunctions.

Highlights of Controlled Studies

Descriptions of eight separate studies of children are presented, plus one case history, which covered several years. (4)

1. Elmer selected 19 children to follow in the clinic for 1½ years. (5) Their economic situation ranged from very poor to comfortable and adequate. His findings suggest that social environment can be a powerful influence on infants who show a "failure to thrive." Other findings suggested that there was a lack of helpful interaction between parents and emphasized the importance of the father.
2. Bullard and others examined several children for psychological and social reasons for failure to thrive after organic causes had failed to be shown. (6) The pattern of findings revealed were: a chronically unstable home situation; erratic living habits in the family; severe marital strife followed by separation of the parents more often than not, and job instability or unemployment of the parents. Often the mothers admitted leaving the child for long periods of time unattended, or attended by strangers. Also, they described a lack of feeling for the child. Feeding methods such as the ones described by Leanord

and associates were identified:

> Constant jostling and pulling the nipple out of the baby's mouth intermittently leads to regurgitation on the part of the baby.—This, in turn, led to further anxiety or irritation anxiety on the part of an already fatigued and anxious mother.
>
> The principal cause of baby's failure to thrive was not just the mother's instability and personality disorders at the time, but also physical overstimulation due to jostling and patting during the feeding. (7)

3. Barbero described a "warding off" behavior with hands or quite often clothes pulled over the face by the children he studied. (8) Their body posture was described as rigid with arms held tightly in front of them, while others in the sample gave posture extremes of lying flaccid and withdrew from social contact. The mothers described the feeding of these infants as a struggle.
4. Krieger and Sargent studied a sample of 21 children. They categorized several symptoms into what they called "Sensory Deprivation Syndrome," of which a typically "infantile posture" was one characteristic. (9) The infant's responses to environmental stimuli were not typical of infants at their chronological age. The nonthriving infants either did not respond at all or reacted in a manner comparable to a fright reaction observed in animals and human beings who remain motionless rather than take appropriate protective action.
5. Powell studied 13 cases of unexplained dwarfism. There were no organic findings except for insufficient pituitary functioning. He commented that 11 sets of parents were separated or divorced. (10)
6. Leanord and others studied a sample of 13 family-reared infants who failed to thrive. They described the same signs as Dr. Bowlby had regarding institutionalized infants. One of their conclusions was that failure to thrive might occur among infants where there is a deficiency of holding or close fondling by another person within the family. The authors strongly recommended that parents be included in the plan of care for these infants.
7. Patton and Gardner have made two separate studies of infants who failed to thrive. (11) (12) One sample had 6 children and the other had 16. These investigators added the dimension of making clearcut recommendations to include social stimulation. In their book, *Growth Failure in Maternal Deprivation*, they have described the reaction of adult volunteers who consented to go through sensory deprivation. These subjects, all normal adults, experienced a pronounced distaste for food during sensory deprivation. In other words, if there is no love and no social stimulation, food loses its appeal and becomes distasteful.
8. Fischoff and others have more recently studied a sample of 12 mothers, who had full-term infants that failed to thrive. (13) For no discoverable physical reasons, the infants had growth failure. In the best judgment of pediatricians, nutritionists, social workers, and others, these infants failed to thrive as a result of maternal deprivation. Their findings showed that the infants were underweight because of undereating. The undereating was determined to be secondary to not being offered enough food. Their recommended course of action was: (a) provide the mother someone to "lean on;" (b) the mother should be shown how to feed, play with, and care for her infant in a "benign, direct, tutorial relationship, usually with a social worker or homemaker;" (c) the mother would be likely to respond best to some kind of intervention involving action, concurrent with supportive counseling; (d) this kind of care program for the infant should extend over a long period of time, allowing the mother a long time to see herself (conceptualize) and how she functions.

Characteristics of the Mother and Environmental Similarities

I. The Fischoff study done in Detroit in August 1971 gave some light on the characteristics of the mother:

   1. The mother of the baby who failed to thrive gave an account of poor performance in current day-to-day activities.
   2. The term "adequately mothered" was explained to the mothers in the study before they were interviewed. The term was explained as having received expressions of love and physical warmth in the form of fondling and verbalization by one's own mother or a caring person in early infancy. After this definition, the mothers said they had been inadequately mothered themselves.
   3. The mothers interviewed in the Detroit study reported an intense need to be taken care of themselves (in all but two mothers in the study).
   4. There was limited capacity for abstract thinking and planning for the future.
   5. Major mechanisms of defense were identified by the investigators as being those of denial, isolation and projection.
   6. It was usually the case that ineffective mothers said they didn't have mothers or if they did, they had very busy mothers who were often upset by overwork and overall family problems.

II. The feeding behavior as reported by mothers to Barbero, Elmer, and Bullard was described as one in which the baby was a poor eater. In ad-

dition, the mothers had very little time to hold the baby, permit him to suck, or to be relaxed, themselves, while feeding him. One investigator described the situation as "a running battle between the mother and baby." Also, the mother was not skilled in the craft of motherhood. Lack of know-how on the part of mothers in feeding methods was pointed out by still another investigation. (7) The few occasions where nonthriving infants were assigned one or two nurses to be the only ones to give care, proved to be the most successful in bringing about a more responsive baby.

Characteristics of the Infant or Child

1. Weight and height below the third percentile.
2. Unresponsive and withdrawn —may fail to smile at a human face or respond to a coo.
3. "Radar gaze" described as staring into space for indefinite periods of time.
4. Lack of crying or other aggressive behaviors.
5. Lack of warmth and friendliness toward anyone.
6. Too easily subdued in the presence of sustained attention. A tendency to reach the saturation point when too much love and attention are given too quickly.
7. Rarely smiles.
8. Submissive but not cooperative.
9. A "warding off" behavior with the hands, or quite often, the clothes pulled over the face.
10. Occasionally, a failure to gain weight in spite of good nourishment.
11. Assumes a typical body posture (sometimes rigid, sometimes flaccid) for long periods of time.

Crucial Age Levels

During the first months of the infant's life, and certainly before 3 years of age, the infant and young child is most liable to damage by lack of maternal love. Between the ages of 3 and 5 years, the risk is still serious, though much less than earlier life. Bowlby has stated of 3-5 year old's, "The children can conceive dimly of a time when their mothers will return, which is impossible to most children younger than 3 years of age. These children can talk and this permits parents simple explanations, and the child will take more readily to mother-substitutes. Therefore, during this age period, it may be said that wise and understanding management can go far to lessen ill effects." After the age of 5 years, the risk diminishes still further; however, these children will not adjust satisfactorily to separations if they are sudden and there has been no preparation.

Characteristics of Infants and Young Children After Treatment

In the study conducted by Patton and Gardner, parents were included in the specialized hospital environment and the staff gave extra time and love to all the infants. (12) One boy in the study showed a remarkable acceleration of growth when parental relationships in his home were greatly improved. The infant, who stayed in the hospital the longest, showed a rapid increase of interest in toys and their use. All but one in the sample improved the symptoms which were present at the time of hospital admission. All except four children had gained weight. One child in the sample had been studied for almost 7 years. She was admitted to the hospital at 13½ months of age. Her height and weight were approximately at the 8-month level. Her expression began to brighten after a few days of special attention. After 4 months in the hospital and 3 months of "mothering," mostly by one nurse, she began to say "mama" or "mother" to the nurse; was sitting without support; rolling at will, and gaining weight rapidly. At 8 years of age, after care in a foster home, she was doing well in the second grade of school and living happily with foster parents. Her physical progress had been good, but psychological testing showed persistent abnormalities in personality structure.

The other study done by Patton and Gardner showed some evidence of persistent damage to personality structure and intellect in all six sampled. (11) There was, however, definite improvement in social behavior, mood and intellectual function.

Elmer studied 19 children for approximately 11 months and reported that all babies showed excellent response when the social environment was considered as part of their care. One child who weighed 11 pounds at the start of the study had gained 7 pounds in the 4-month period. Another child, 2½ years old, began to walk and talk and showed excellent weight gain.

In 1966, a group of retarded children at Central Colony in Madison, Wisconsin, were given special team care (physical therapist, nurse, nutritionist, pediatrician, social worker) to see if a multi-professional plan of care might assist the children in learning, positioning, socialization, and other positive benefits. All children in this control group gained weight and increased in height. Nurses who were part of the study reported that added attention and love was directly related to children's appetites and growth spurts. (14)

Barbero found that a high level of eye contact and visual awareness became evident very soon after hospitalization when special love and attention were an essential part of care.

> Weight gain may take longer and may transpire only after an environmental change either in or out of the home setting (Barbero).

There was significant weight gain in all four of the study samples. This occurred after appropriate environmental stimulation and feeding had been instituted. Subsequent acceleration of development showed that the improvement was of clinical significance, indicating reversibility of

developmental retardation. The retarded growth originally identified was directly related to inappropriate nurturing within the familial and foster care setting.

Challenges for the Future

1. Psychological and environmental studies should not be deterred by studies being done in the area of chromosomal analysis, including inborn metabolic disorders.
2. "Individual vulnerability" should be defined.
3. A definition of "deprivation" at chronological age levels in growth and development norms should be determined.
4. Additional studies should be made utilizing the natural mother as the "mothering" person on the hospital team. Both parents or a caring person at home should be part of the ongoing care of hospitalized infants. The nurse is vitally involved in meeting this particular challenge in a variety of settings both inside and outside the home.
5. A more careful assessment of parent-child; mother-child; parent-parent relationship is needed.

Some additional and very specific unanswered questions have been highlighted in the preliminary study of Leanord and associates:

1. What are the effects of developmental stages on the manifestations of failure to thrive?
2. How well can limits be defined of failure to thrive and genetic smallness?
3. Which psychologic factors are most significant in interfering with the thriving of an infant and his mother?
4. If there is an inherent vulnerability on the part of some infants, how do we first define it and then recognize this trait in time to give appropriate intervention?
5. How can parents be reached more effectively?

The answer to the last question can be found partially in another challenging area for future study. It is this: A more careful assessment of parents' *know-how* in caring for infants. There may be a real need for a role model in the care of a baby. A more careful assessment of parents' understanding of realistic beginning behavior of infants is also needed.

Implications for the Nurse

Being one of the first people on the scene, the nurse can use her observation skills and assessment tools in early casefinding of infants who fail to thrive. She can refer these infants for early diagnostic studies and concurrently provide mothers or parents with supportive counseling. In addition, the nurse has an opportunity to provide followup through home visits and can assist the family in carrying out recommendations made by the diagnostic and evaluation team. Trends in delivery of health care are moving in the direction of collaborative care on the part of the nurse. This means that she must be ready to serve as a member of the interdisciplinary team in evaluation as well as provide home followup reports.

Rhymes demonstrated in her study of a non-thriving infant that it is possible for the nurse to serve as a model in mothering while caring for the infant in the hospital. (15) The nurse was able to observe the natural mother's readiness to care for her infant and gradually have her assist in his care. After the baby went home, the mother was able to properly care for the baby herself.

Systematic recording of observations by the nurse is a valuable tool in laying sound groundwork for her own conclusions. Her plan of care and implementation show promise of making a real contribution in helping babies who fail to thrive and their families.

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The Neurological Evaluation of Infants and Young Children

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Discussion of Child's Problem with the Parents

The presenting complaint and the child's difficulty as described by the parents should be carefully recorded. This will include a history of convulsions, trauma, severe illness and comparison of this child's development with that of older siblings where possible. If the child shows an obvious developmental lag or has cerebral palsy, the term handicapped child may be used in discussing the child's difficulty with parents who may not yet be ready to accept the term mental retardation.

The Neurological Examination of Infants and Young Children

Examination of the child presents special problems as a number of neurological disorders are peculiar to childhood, and certain disorders are frequent in childhood and may be closely related to mental subnormality.

Comprehensive assessment and good management will include a complete history of the pregnancy and birth, developmental information, and a review of familial, genetic, and environmental factors. The birth record should be obtained whenever possible. Many neurological disorders are familial; they tend to occur with greater frequency in some families than in the random population without having clear evidence of regular genetic transmission. The severe congenital malformations of the central nervous system, anencephaly and meningo-myelocele also appear to run in families with a greater risk of recurrence in siblings.

Suspicion of Mental Retardation

This arises if an infant has a weak cry, poor suck, swallowing difficulty, inactivity, flaccidity, spasticity, or persistent drooling. Slowness in the development of early motor milestones—including delay in developing good head support—and abnormalities of visual pursuit of persons and objects are of prime importance. Delays in sitting, reaching and grasping, crawling, standing, walking and in growth may be noted. A suspicion of abnormality on the part of the mother, who has older children, is frequently confirmed.

Normal infants may begin to smile when spoken to before the age of 4-6 weeks, but not much later. They may begin to grasp objects by 4 months of age, but not later than 6 months; or may begin to chew by 5 months, but not much later than 7 months. Babble appears at 5-6 months and repetitive syllables at 9-12 months. In older children slow or impaired speech development, behavior disorders, and poor school performance frequently raise a question about defective intellect. An estimate should be made of alertness in all infants and the degree of interest they show in their surroundings should be carefully noted.

The Neurological Examination

Complete general and neurological examinations are carried out with special attention given to a search for congenital anomalies, skin lesions and unusual appearance. The shape of the head is noted and its circumference measured, so that microcephaly and macrocephaly can be ascertained. Translumination of the skull is carried out on all infants under 1 year of age and the fontanels inspected. (3) The examination will also include a search for chronic motor deficits and abnormal infant reflex patterns. Small infants held in ventral suspension may adopt an abnormal position with flexion of the neck and extension of the legs in certain non-progressive encephalopathies.

The state of the infant at the time of the examination is important. Sleepiness or wakefulness, hunger or satiation may alter the reactions to be tested. Fundoscopic examination, examination of the mouth, and plantar responses elicitation—all integral parts of the evaluation—should be assessed.

The quality of a small infant's cry will be noted. An infant will follow a 4 cm. red disc 90 degrees at or shortly after birth and through 180 degrees by 3

months. Extraocular movements can be tested in small infants by rotating the infant in the examiner's arms. There is a head lag in pulling the infant to a sitting position shortly after birth. The extensor muscles of the neck are strong in contrast to those of the limbs and trunk. Good head support should be developed by 3 months. Athetoid movements may be noted in certain infants with brain damage.

In older infants and young children the examination may begin with play. Most children will stack six cubes by 24 months and place marbles in a container and apply the cover by 18 months. Normal young children will scribble at 2 years and draw a circle by 3 and a cross by 4.

Cranial Nerves

1. Usually not tested. Certain nerve functions are tested concomitantly. Visual pursuit tells something about 2, 3, 4 and 6.
2. Test visual fields with 4 cm. red disc or face.

3, 4, 6. Reaction of pupils to light and accommodation. Doll's head phenomenon, optokinetic nystagmus.

5. Pin prick, corneal reflex. Chewing and opening of mouth (note deviation of jaw).
7. Spontaneous movements, smiling, crying (note naso-labial folds).
8. Auditory stimulus to either ear. Sound may cause cochleo-palpebral reflex or general startle or modification of rhythm of breathing. Acoustic orientation appears later than visual orientation. After a few weeks when the mother speaks, the child may stop moving and look at her; later he turns toward the sound of a falling object.

9, 10. Gag reflex. Palate elevation with vocalization.

11. Rooting reactions from tactile stimulation of lips.
12. Tactile stimulation of mouth yields tongue deviation. Lower lip stimulation, tongue protrudes, and licks lower lip.

Motor Function

Some increase in resistance to passive movement is noted from 1-2 months of life. Spontaneous movements at rest are noted-symmetry versus asymmetry of these movements. Muscle tone should be evaluated, the consistency of muscles palpated and passive movement of all extremities carried out.

Sensation

Pin prick, touch, vibration. Posterior column sensation can be evaluated through placing reactions.

D.T.R.'s

Biceps jerks are present at birth. Flexion tone decreases by the fourth month of life in upper extremities. Knee jerks increase and triceps and ankle jerks appear.

Plantar responses are often flexor in the first month and frequently flexor by a year, but variable until 24 months. (1) (6) (9) (10)

Gait

Positive supporting reaction and stepping are present at birth, but sometimes not elicitable from 2-3 months. True contact placing develops by 5-6 months.

Useful automatisms have been listed in Table I. Many of these are of considerable practical use. Paine in a 5-year study of abnormal evolution of automatisms noted in a prospective study of 129 babies: (7)

1. Failure of reaction or response to appear.
2. Persistence or recurrence after the time the reflex should disappear.
3. Abnormal quality of response or asymmetry.

Myelination and the Development of Function of the Nervous System

It is generally assumed there is an intimate relationship between myelination and the function of the nervous system. Diseases associated with progressive demyelination produce conspicuous functional disability.

Myelination of white and gray matter begins about the fourth fetal month; it increases rapidly following birth. It is moderately complete by the end of the second year of life, but continues in diminishing degree until puberty.

Myelination appears first in phylogenetically older tracts; it develops parallel with function (8) Vestibulospinal tracts are myelinated by the end of the fifth or sixth fetal month (affects muscle tone and motor movement). The pyramidal tracts possess relatively little myelin at birth, but the amount has increased greatly by the end of the first year of life when the infant begins to walk. Myelination of cerebral association fibers is slow in appearing and progresses until puberty.

At birth coronal sections of the brain appear diffusely gray. The cortex and basal nuclei are outlined dimly resulting from the lack of myelin. Only a few fibers of the cortical hemispheres are myelinated at this time.

There is a priority in myelination given to the afferent systems. (8) All the pathways of sensation and equilibration are myelinated very early generally from below upwards. At the level of the cord, on the other hand, the anterior roots are myelinated before the posterior roots. The cranial nerve roots are myelinated very early especially the vestibular root. The activities of the newborn infant are all reflexes mediated by the spinal cord and the brain stem. Instances have been observed of infants, showing all the normal reactions including crying, nursing, and vigorous movements, who were found at autopsy to have no cerebral hemispheres. This indicated the cortex plays little part in early neonatal activity.

Table I.
Useful Automatisms and Milestones

Neurological Sign	Range When Present
Follows 4 Cm. Red Disc	Birth 30°—3 months 180°
Smiles	6 weeks—persists
Spontaneous Stepping	Birth—2-6 weeks
Positive Supporting	Birth—3-6 weeks
Trunk Incurvation	Birth—1-2 months
Supports Head Well	2-3 months
Moro Reaction	Birth—4-5 months
Placing Anterior	Slow at birth—quick by 4 months
Placing Medial and Lateral	5-6 months
Rooting	Birth—4 months
Tonic Neck Reflex	2-5 months
Landau	3 months—12-24 months
Traction Grasp	Birth—4 months
Grasp Reflex	3-5 months
Instinctive Grasp (4)	Supination 4-6 months
	Pronation—4-6 months
Pursuit and Grasp	6-7 months
Thumb and One Finger Grasp	9-10 months
Neck Righting	4-6 months—12-24 months
Positive Supporting	6 months—persists
Parachute	7-8 months—always present by one year
Sits if Placed (5)	5 months
Sits with Lateral Prop	8-9 months
Sits with Posterior Prop	12 months or later
Stands Holding On	9 months
Walks unsupported (6)	9-14 months

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Genetic Aspects of Mental Retardation

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Introduction

This presentation is concerned with the genetic aspects of mental retardation syndromes. It will attempt to show the importance of genetic considerations in the field of mental retardation and to indicate ways in which the geneticist can and should aid in the overall management of patients with mental retardation syndromes and provide counsel to their families. This lecture shall draw freely from the articles of Dr. John M. Opitz, a former colleague, to whom the author attributes much of the knowledge he has gained in the field of medical genetics. (1) (2) (3) (4)

The first paragraph mentioned mental retardation syndromes. Literally, the term syndrome means running together. In considering the term here, I will define it as the concurrence of clinical features in a patient, and further, the concurrence of a similar spectrum of clinical features in multiple patients, the frequency of the concurrence being high enough that it cannot be attributed to chance alone.

Penrose has indicated that the peak frequency of mental retardation in 12–year–old children is 3 percent. (5) The frequency in younger populations has, for the most part, been lower. He infers that this is due, in part at least, to the fact that not until the ages of 10 to 14 years are standardized tests available for the accurate determination of intelligence. A less likely explanation might apply: A significant number of mentally retarded children may acquire their mental retardation, because of trauma, infection of the central nervous system (meningitis, encephalitis), or as genetically determined conditions which first manifest themselves at several months or years of age. Obviously, in the infant, mild degrees of mental deficiency are difficult to determine. If the defect is mild, it may not be noticed until the child enters school, when distractability, short attention span and learning disabilities become problems. Conversely, in syndromes which result in early death (chromosomal aneuploidy and inborn errors of metabolism), mental deficiency may not be diagnosed because the early death intervenes. It follows, then, that at least 3 percent of all infants born, and probably more, are destined to be mentally retarded. An accurate diagnosis, made as early as possible, is a necessity for the following reasons:

1. An accurate diagnosis is a must if:
   a. hope for specific therapy is to be entertained. To date, only a few mental retardation syndromes are amenable to specific therapy, but such therapy is impossible without accurate diagnosis.
   b. accurate genetic counseling is to be possible. The recurrence risk may vary from negligible on one extreme to 100 percent on the other.
2. An early diagnosis is required if:
   a. the specific therapy is to have any success. In galactosemia, for example, early initiation of a galactose-free diet provides a much better prognosis for intelligence than if the dietary therapy is delayed for 6 to 12 months.
   b. genetic counseling is needed. With a mortality rate as high as is encountered in such conditions as chromosomal aneuploidy, a diagnosis must be made in early infancy or it cannot be made at all.

The Mental Retardation Syndrome

A mental retardation syndrome involves mental retardation in association with anomalies of other organ systems, including the craniofacies, the cardiovascular system, the genitourinary tract, the skeleton, the integument, and others. Such anomalies may be major—of medical, surgical and/or cosmetic consequence to the patient; e.g., congenital cardiac defect, spina bifida cystica or severe cleft lip/palate, or minor—one which does not impair the health of the patient, but which may impair his social acceptability; e.g., malformations of the external ears, hypertelorism, dermatoglyphic features, hirsutism, abnormal skin pigmentation, or syndactyly of mild degree. Most

of the anomalies encountered in a mental retardation syndrome, regardless of its etiology, are of the minor variety. However, when one approaches the patient, he must keep in mind that minor anomalies may be important indicators of more serious involvement. This is not to say that the presence of a minor anomaly in a single person (a frequent occurrence in the general population) is of dire consequences.

In a study of 4,412 newborn infants, Marden, Smith and MacDonald found by surface examination a single minor anomaly in 13.3 percent of otherwise normal infants, two such anomalies in 0.76 percent of otherwise normal infants, and three in less than 1 in 2,000 infants without a major anomaly. (6) It would seem, then, that the presence of three or more minor anomalies should alert the examiner to the possible presence of a major defect. Smith and Bostian examined 50 children with idiopathic mental retardation (cases in which a diagnosis had not been made) for the presence of anomalies. (7) Forty-two percent had three or more anomalies; 80 percent of which were minor. In an equal number of normal control children, none had as many as three anomalies. Thus, mental retardation is an important "major anomaly" to which we should be alerted by the existence of multiple minor anomalies. Even in the well known mental retardation syndromes, such as Down's syndrome, the Hurler syndrome or the Noonan syndrome, most of the anomalies are of the minor variety.

In view of these facts, every patient with mental retardation should have a thorough "constitutional" physical examination for the documentation of all anomalies, with a complete description (including certain negative as well as positive findings), measurements when possible, photographs and dermatoglyphic analysis.

As discussed by Opitz, the definition of any syndrome passes through three levels of specificity. (1) (2) (3) (4) The first and most superficial level is the Physical Examination syndrome, the presence of two or more anomalies in an individual. An example is the child who is brought in to the physician because he "looks different;" he may be unlike his parents and siblings in appearance. The physician realizes that the child is anomalous, but cannot make a diagnosis. Through contact with colleagues he collects several patients with a series of similar or identical anomalies. For these anomalies to occur in several patients, a common or similar pathogentic process must be operative. This constitutes the next stage of syndrome specificity, the Formal Genesis syndrome. However, the operation of a common pathogentic process in several similar patients does not necessarily indicate a common etiology or causal genesis. For example, cleft lip, similar in appearance in several patients, may have a different etiology in each. The third and most specific level of syndrome definition is the Causal Genesis syndrome, the concurrence of causally related anomalies. The Causal Genesis syndrome, in genetic terms, can be further subdivided into the *definitive* Causal Genesis syndrome and the *preliminary* Causal Genesis syndrome. Examples of the former include those caused by a chromosomal abnormality, a definable biochemical error, an identifiable teratogenic agent, or those exhibiting a definite genetic mode. The latter applies when no etiology is definable and when the pattern of inheritance does not follow basic Mendelian principles, or when cases occur in an obvious familial distribution. Because of the very nature of a Causal Genesis syndrome, several principles may apply:

1. A Causal Genesis syndrome may be defined upon the basis of the investigation of only a single patient, if in the case a definite causal genesis is discovered.
2. The same Causal Genesis syndrome may be defined in two or more apparently dissimilar patients, if the same basic etiology can be demonstrated in all cases.
3. When a syndrome is first defined, the cases which attract the attention of the observer are those most obviously different from the normal population. For this reason, a false impression may be created concerning the spectrum of the syndrome under investigation. Once such "typical" cases are well described, observers may often be able to recognize less severely affected cases and thus define the total spectrum of the syndrome. Definition of this spectrum can be enhanced by close scrutiny of first degree relatives of probands. Opitz has suggested that such examination be limited to siblings born after ascertainment of the probands. (1)
4. As discussed further by Opitz, no two cases of any given syndrome are exactly alike:
   a. No characteristic or syndrome-specific anomaly exists in *any* syndrome. For example, webbing of the neck (pterygium colli) is a well known component anomaly of the Turner syndrome. However, webbing is not limited to the Turner syndrome and is known to occur in other conditions as well.
   b. No obligatory anomaly exists in *any* syndrome: i.e., no anomaly is a sinequanon of a syndrome. In the Turner syndrome, webbing occurs in only about 50 percent of cases, and its absence in any given suspected case by no means lessens the likelihood of the Turner syndrome.
   c. The penetrance—or frequency—of a given anomaly varies in the several syndromes of which it is a component part.
   d. The expression—or severity—of a given anomaly varies from patient to patient with the same syndrome.
   e. An anomaly may change with advancing age of the patient, e.g., inner epicanthal folds often disappear

as the child grows and his face matures.

An example of the process of definition of a syndrome, from its early observation to its detailed description, is the Turner syndrome. In 1938, Dr. H. H. Turner described seven women who were short of stature, had webbing of the neck, cubitus valgus and primary amenorrhea, were sexually infantile and sterile. (8) At that time he did not know the etiology of this condition. In the ensuing 22 years, knowledge of the pathogenesis and phenotypic spectrum was accumulated. It became apparent that such patients ordinarily have gonadal dysgenesis, with streaks of nonfunctional tissue instead of ovaries, along with numerous somatic anomalies.

When the condition was reported by Turner, it was nothing more than a Physical Examination syndrome. However, several observations confused the issue. First, certain women with many of the somatic features of the Turner syndrome were not short of stature; had evidence of gonadal function, including menses and fertility; and while the intelligence of most patients was not below the normal range, a few were obviously mentally retarded. Second, the somatic phenotype of the Turner syndrome, in some cases with obvious hypogonadism, was also described in males. Such males were said to have the "male Turner syndrome." (9) The advent of sex chromatin determination brought the syndrome one step nearer to an etiologic definition.

Sex chromatin studies revealed that nuclei of cells from buccal smears of the majority of women with the Turner syndrome lacked a sex chromatin mass (are sex chromatin negative) as do cells of a normal male. The nuclei of cells from buccal smears of normal females contain a sex chromatin mass (are sex chromatin positive). The absence of a sex chromatin mass from cells of apparently affected women was by no means uniform; furthermore, the apparently affected women, who had menses and were fertile, were sex chromatin positive. Victims of the "male Turner syndrome" had sex chromatin patterns identical to that of the normal male. In 1959, Ford and coworkers found that cells from the sex chromatin negative females with the Turner syndrome contained only 45 instead of the normal 46 chromosomes, and concluded that the missing chromosome was an X. (10)

Subsequently, the chromosomal spectrum of the Turner syndrome was broadened, but still involved partial or complete absence of one X chromosome. Still, a few patients confused the issue as they had no chromosomal abnormality. These were the patients who had menses and were fertile. In addition, more detailed studies revealed that these fertile females with some stigmata of the Turner syndrome and males with the "male Turner syndrome" may occur in the same family. (11) This and other phenotypic similarities between such females and males led to the conclusion that they do not have the Turner syndrome after all, but have a nosologically and genetically distinct condition that does not involve a chromosomal abnormality. We have called the condition the Noonan syndrome. (12) (13)

As a result of this evolution, a syndrome previously thought to be a single Physical Examination syndrome—later Formal Genesis syndrome—is now known to be two distinct Causal Genesis syndromes. The Turner syndrome is a definitive Causal Genesis syndrome; the Noonan syndrome remains a preliminary Causal Genesis syndrome. It does occur in a familial distribution, but its exact genetic mode is not known.

Types of Syndromes

Now let us consider specific examples of mental retardation syndromes, dispensing first with environmentally induced syndromes. The best known of these is the syndrome produced by intrauterine infection with rubella virus, although other viral infections are also known to produce severe central nervous system damage. Such conditions often occur as spatially and temporally related "clusters," but do not occur as genetically related cases. The severity of an environmentally induced syndrome varies depending upon the stage of gestation at which the offending agent is introduced, its duration of action and probably its dose.

The remainder of this discussion will deal with genetically determined syndromes; specifically with genetic counseling considerations of these conditions. As mentioned previously, a prerequisite for accurate genetic counseling is an accurate diagnosis. Once a nosologic diagnosis is made, counseling information must be based upon the mode of inheritance for the syndrome in question. Probably the most exhaustive available sources of such information are: "Mendelian Inheritance In Man," 3rd edition, by Victor A. McKusick, and "The Proceedings Of The First Conference Of The Clinical Delineation Of Birth Defects: Original Article Series," Vol. V.

One need only survey these publications to realize that the greatest obstacle to establishing a definite genetic mode, especially in sporadic cases (patients with no affected relatives) is genetic heterogeneity. As discussed previously, similar genetically determined phenyotypes may be the results of quite different genetic mechanisms. Genetically determined syndromes may be classified as follows:

1. Syndromes determined in a defined Mendelian fashion. A comprehensive discussion of Mendelian inheritance is not within the scope of this lecture, but such discussions are available in standard texts on medical genetics. (14) (15) (16) (17)
   a. Syndromes inherited in an autosomal dominant manner. Such syndromes are produced by a mutation involving a gene located in one of the 22 autosomes (non-sex chromosomes). The vast majority of victims of autosomal dominant mental retardation syndromes are heterozygous: i.e., have one mutant

(dominant abnormal) allele and one (recessive) normal allele of the gene in question. Further, most matings involve an affected person and a normal spouse. Based upon these restrictions the gametes produced by the normal spouse can contain only the normal allele of the gene which, when mutant, produces the syndrome in question. Gametes produced by an affected spouse may contain either the normal or the mutant allele, with equal probability. Thus, the offspring of such a mating may be affected or normal with equal probability. On the average, certain rules can be formulated:

1. An affected person ordinarily has one affected parent (unless the affected person is the result of a spontaneous mutation in a parental gamete).
2. Half of the offspring of an affected person are affected, half are normal.
3. Half of the siblings of an affected person are affected, half are normal.
4. Members of both sexes are affected with equal frequency.
5. An unaffected sibling or offspring of an affected person cannot pass the abnormality on to his or her offspring, assuming that the unaffected person does not carry the nonpenetrant mutant allele of the gene in question. Some persons may be heterozygous for the mutant allele and yet not manifest its effects. In such persons the gene is said to be nonpenetrant.

One must keep in mind that most, if not all, of these general rules have exceptions, and each case must be judged upon its own merits. The family history is all important in evaluating the heritability of any condition. Attention is directed to the vertical distribution of cases in dominant pedigrees; i.e., persons are affected in succeeding generations of the family as well as in the same sibship. A striking example of autosomal dominantly inherited mental retardation syndrome is a type of acrocephalosyndactyly called Apert's syndrome. This involves mental retardation, severe craniofacial dysmorphology and complete syndactyly of most of the digits of the hands and feet. Based upon the rules of autosomal dominant inheritance, certain probabilities must be conveyed to the parents of an affected child:

1. If both parents are normal and if the family history is completely devoid of other affected members, one may reasonably conclude that the affected child is the result of a new mutation in one of the parental gametes. The risk of another affected offspring to the same parents is probably no greater than for any other parents the same age (keeping in mind that some evidence exists for an increased spontaneous mutation rate for some dominantly inherited conditions in older fathers).
2. If one spouse is affected, the risk of an affected child with any pregnancy is 50 percent.
3. The risk of an affected child to an unaffected sibling of any affected person is no greater than that to any unrelated, unaffected person.

b. Syndromes inherited in an autosomal recessive manner. These syndromes are complex, often incompatible with prolonged life, and if compatible, produce severe mental defect and decreased fertility. Autosomal recessive inheritance is the most frequent pattern thus far discovered in mental retardation syndromes. Unlike the situation in autosomal dominant inheritance, the person who harbors one normal (dominant) allele and one (recessive) mutant allele of the gene in question (is heterozygous) is phenyotypically normal. Only those persons who are homozygous have two recessive mutant alleles of the gene in question, manifest the clinical effects of the mutant allele. As long as the mutant allele is maintained in the heterozygous state, its clinical effect will not be observed, and it can be passed undetected through numerous generations of a family. Only when a heterozygote by chance marries another heterozygote can an offspring be homozygous and manifest the syndrome in question. Based upon the probabilities inherent in such a mating, several general rules may apply.

1. Both parents of an affected person are unaffected.
2. One-fourth of the siblings of an affected person are affected, one-half are heterozygous for the mutant allele (unaffected but carriers) and one-fourth are homozygous normal.
3. The two sexes are affected with equal frequency.
4. Unless an affected person marries another person affected with or heterozygous for the genetically identical condition, all his or her offspring will be unaffected.
5. An unaffected sibling of an affected person has a 2/3 probability of be-

ing heterozygous for the mutant allele in question.

Examples of autosomal recessive mental retardation sydromes include the Hurler syndrome and the syndrome of total lipodystrophy. Of course, if clinical criteria alone are employed, the physician has no way of knowing that both man and wife are hetterozygous for an autosomal recessive syndrome until they have had an affected child. Once the affected child allows such recognition, the parents must be informed that with each succeeding pregnancy the risk of a similarly affected child is 1 in 4 or 25 percent. In contrast to the autosomal dominant pedigree, the affected persons in recessive pedigrees are limited ordinarily to one generation, and even more to one sibship. The physician must maintain an awareness of newly discovered autosomal recessive syndromes, keeping in mind that an accurate diagnosis is mandatory for accurate genetic counseling. Furthermore, since human family size is small, in a condition in which the probability of an affected child is 1 in 4, most cases will appear to be sporadic: i.e., will be the only affected child in the family. In some recessively inherited conditions, heterozygotes can now be ascertained by special techniques; furthermore, a diagnosis of some such conditions can be made on the unborn infant by means of special techniques for study of aspirated amniotic fluid. (18) (19)

c. Syndromes inherited in an X-linked dominant manner. Thus far discussion has considered only those conditions produced by mutant alleles of genes located in the autosomes. Consideration will now be directed to mutant alleles of genes located in the X chromosome. While the female has two X chromosomes and may be either homozygous or heterozygous for any allele located therein, the male has only one X and is said to be hemizygous for genes located therein. Any gene in the hemizygous state will manifest its effect, whether it is dominant or recessive. The proportion of affected and unaffected children of a mating between an affected and an unaffected person depends upon the sex of the affected person. Consideration will be given only to matings between affected and normal persons, since these account for most matings which produce affected offspring. If the wife is affected, she will produce gametes containing the mutant allele and the normal allele in equal proportions. If the husband is affected, his X-chromosomé-bearing sperm must carry the mutant allele; his Y-chromosome-bearing sperm cannot carry the mutant allele. Consequently, several general rules can be established.

1. Half the offspring of an affected woman will be affected, half will be unaffected, regardless of the sex of the offspring.
2. All of the female offspring of an affected man will be affected, whereas all male offspring will be unaffected (male to male transmission does not occur).
3. An affected male has an affected mother; an affected female may have an affected mother or an affected father (unless the affected male or female is the result of a new mutation in a parental gamete).
4. Half the male and female siblings of an affected person whose mother is also affected are affected, half are unaffected.
5. All the sisters of an affected female whose father is affected are likewise affected, all brothers are unaffected.
6. An unaffected person cannot pass the condition on to his or her offspring, assuming the unaffected person does not carry the nonpenetrant mutant allele.

An important caution in applying these rules is that females who are heterozygous for a dominant X-linked mutant gene may vary in severity from clinically normal to severely affected due to the nuances of the Lyon Hypothesis, a discussion of which is beyond the scope of this chapter. An example of an X-linked dominant mental retardation syndrome is Albright's heredity osteodystrophy, which can produce (in addition to mental deficiency) convulsive seizures, shortness of stature and other somatic abnormalities. (19) If either husband or wife has such a condition, counseling information should be specific, as follows:

1. If the wife is affected, the probability of any pregnancy's producing an affected offspring is 1 in 2 (50 percent) regardless of the sex of the offspring. If the affected offspring is a female, she may be quite mildly affected; if a male, his condition will ordinarily be more severe.
2. If the husband is affected, all the daughters will be affected; none of the sons will be affected.

d. Syndromes inherited in an X-linked recessive manner. Here a mating which produces affected offspring or-

dinarily involves a heterozygous (but unaffected because the gene is recessive) female and an unaffected male, who carries the normal allele of the gene in question in his one X chromosome. In such a mating, the gametes produced by the heterozygous wife contain the X chromosome which bears the normal allele and harbors the mutant allele in equal proportions. The X chromosome in the X-bearing sperm cells produced by the father is normal. Ordinarily, the following rules apply:

1. Half of the sons of a heterozygous mother will be affected, half will be normal.
2. All the daughters of a heterozygous mother will be affected, but half will be heterozygous for the mutant gene in question.
3. Affected sons have normal parents, but the mother is heterozygous, unless the mutant allele in the son is the result of a new mutation in the maternal gamete.
4. An affected daughter can result only from a mating between a heterozygous woman and an affected man, an extremely unlikely situation except in matings between cousins or other close relatives.
5. Half the brothers of an affected male are affected, half are normal; all his sisters are unaffected but half are heterozygous for the mutant allele.
6. An unaffected male cannot pass the syndrome on to future generations. Similar to the situation in autosomal recessive inheritance, a mating between a wife heterozygous for an X-linked recessive mutation and a normal husband is not discovered unless it produces an affected son. Once that happens, genetic counseling should include the information that with each ensuing pregnancy, if the product is a boy, he has a 1 in 2 (50 percent) probability of being affected; if the product is a girl, she will be unaffected. Thus, the overall probability of an affected child with any pregnancy is 1 in 4 or 25 percent. Again, as in autosomal recessive inheritance, females heterozygous for certain X-linked recessive mutant genes can be detected by special techniques, and a diagnosis of an affected fetus can be made on cells from amniocentesis. If the sex of the unborn infant is female, she cannot be affected; if the sex is male, the test can then be applied. Sisters of affected males, sisters of the unaffected heterozygous mothers of affected males, and sisters of other known heterozygous females should undergo such testing. Probably the X-linked recessive mental retardation syndrome, which has been most exhaustively studied recently, is the Lesch-Nyhan syndrome, which is characterized by mental retardation, choreoathetosis, self-mutilation and hyperuricemia. (21)
2. Syndromes with genetic clustering in which the mode of inheritance does not follow simple Mendelian rules and probably is based upon two or more mutant genes acting in concert. The most commonly encountered such conditions involving mental retardation are the abnormalities of the spinal axis, anencephaly and spina bifida cystica. Here, recurrence counseling is based only upon empiric risks: i.e., risk figures collected through the study of recurrence in large numbers of families containing one or more affected persons. In these syndromes, the occurrence is about 2 per 1,000 live births. Once a normal couple has had an affected offspring, the risk of a second one being affected is about 4 percent. The risk is increased, but still relatively low compared with recurrence risks in simple gene defects.
3. Mental retardation syndromes produced by gross chromosomal abnormalities. Although a comprehensive discussion of this subject is not a part of this presentation, several points are pertinent. The frequency of each individual autosomal dominant or recessive mental retardation syndrome in the population is less than 1 in 10,000 live births. On the other hand, one single chromosomal syndrome, Down's syndrome (mongolism) occurs in about 1 in 700 live births—over 10 times the frequency of any single gene-determined syndrome. Frequencies of various chromosomal abnormalities are as follows:

   Down's syndrome—1 in 700
   18 trisomy syndrome—1 in 3,000
   18 (D_1) trisomy syndrome—1 in 5,000
   Turner syndrome and variants —1 in 3,500 females
   Klinefelter syndrome—1 in 450 males
   XYY anomaly—1 in 1,000 males*
   Poly X anomalies—1 in 1,500 females*

   When these figures are totaled, at least 1 liveborn baby in 200 has a gross chromosomal abnormality. Reports by Walzer and Sergovich have indicated that the frequency of chromosomal abnormalities in newborns is 0.5-1.0 percent. (22)(23) In general, every chromosomal abnormality involving the autosomes produces significant mental deficiency as well as some of those involving the

* Rough estimates only

sex chromosomes. Stewart and co-workers found a chromosomal abnormaliy in 4 percent of 184 children with multiple congenital anomalies. (24) Chen and Sergovich found the frequency of chromosomal abnormalities to be greater in low birth weight mental retardates than in those of normal birth weight. (25) Studies, by Dr. Klaus Patau at the University of Wisconsin and by our laboratory, of over 400 children with mental retardation and at least three minor and/or major congential anomalies have revealed that about 12 percent have microscopically discernible chromosomal abnormalities. (26)(27)

4. Even after all these categories of genetically determined mental retardation syndromes have been considered, a significant number of familial cases of mental retardation remain in which no genetic mode has been determined. Opitz has suggested that as many as 50 percent of institutionalized familial cases remain undiagnosed. Smithells has suggested that if parents of normal intelligence have one child who is mentally deficient, but who does not fit into any of the previous categories, the risk of a second affected child is about 18 percent. (28) If one parent is also mentally deficient, the risk of a second affected child is about 30-50 percent, and if both parents are mentally subnormal, the risk of a second affected child is at least 90 percent.

Conclusion

It is obvious from this discussion that every child being evaluated for mental retardation must have a genetic investigation, employing a thorough family history, complete physical examination, and all indicated laboratory procedures. Unless such an investigation is carried out, accurate genetic counseling is impossible, appropriate therapy may not be forthcoming and the program of management of the patient is incomplete.

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Inborn Errors of Metabolism and Mental Retardation

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As early as 1902, Sir Archibald Garrod proposed the concept of inherited enzyme defects or "inborn errors of metabolism." Over 70 years have passed since that time and relatively little is known about these disorders; although knowledge of the subject is accumulating at an accelerated rate.

By definition these disorders occur in family groups and often manifest in a predictable fashion. Most inborn errors of metabolism are recessively inherited through a single autosomal gene, each parent heterozygous or a carrier for the trait, passing the defect to their offspring according to a known Mendelian ratio. Thus, by identification of an index case in a family, the clinician can knowledgeably counsel parents, siblings and other family members regarding recurrence risks. The index patient can also be counselled about his or her risk for producing a similarly affected offspring.

Clinical manifestations of inborn errors of metabolism are extremely varied and the purpose of this discussion is not to enumerate them. Although not a constant feature, mental retardation or overall developmental delay are frequently associated. The exact incidence of this association is uncertain. Yannet in studying 2,000 patients with mental retardation found that 21.6 percent were the result of various inborn errors of metabolism.

Since the disease process is diffuse rather than focal, one should expect widespread and non-lateralizing manifestations, such as diffuse neurologic deficits or overall growth retardation. A history of prenatal or perinatal abnormalities is frequently absent contrary to the history in the congenital rubella syndrome or perinatal asphyxia. Thus at birth, most affected individuals with an inborn error of metabolism lack outward, visible stigmata of disease and most are free of major congenital anomalies.

The postnatal course of an inborn error of metabolism is variable. A rapidly deteriorating and fulminant course is the rule in maple syrup urine disease, while a much slower but progressively deteriorating course occurs in either phenylketonuria (PKU) or galactosemia. Still other inborn errors do not become manifest for ten or more years such as Wilson's Disease.

In summary then, criteria which should alert the nurse or other health professionals to the possibility of an inborn error of metabolism are:

(1) A positive family history for the same or similar disease pattern;
(2) Parental consanguinity;
(3) Diffuse or non-focal central nervous system dysfunction as manifest by overall developmental delay or mental retardation (infantile myoclonic seizures are often associated with a metabolic encephalopathy);
(4) Absence of significant prenatal and perinatal high-risk factors.

Once suspected, the diagnosis of an inborn error of metabolism depends upon delineation of specific clinical manisfestations and the qualitative and quantitative analysis of various bodily fluids and tissues. In the United States, regional centers exist to aid in diagnosis and management of such disorders yet early identification and intervention in the disease process remain the responsibility of the "grass roots" health team. Obviously the earlier diagnosis takes place, the sooner these inborn errors can be treated. The rapidly growing central nervous system in the first 6 months of postnatal life is a prime target for deranged metabolism.

To aid physicians and nurses in early recognition of inborn errors of metabolism, certain screening studies have been devised. The most widely used in this country is the Guthrie bacterial inhibition assay for PKU performed by law as routine screening for all newborns in most states. Massachusetts screens all newborns for a variety of inborn errors in addition to PKU, e.g., galactosemia, maple syrup urine disease, and an assortment of aminoacidurias. Regional centers such as the University of Tennessee Child Development Center screen the urines of all patients admitted for study to look for metabolic disorders in association with developmental disabilities. Ordinarily most screening studies are performed on urine;

however, the bacterial inhibition assays by Guthrie are an exception to this, utilizing patient serum. Ideally urine and plasma are compared for aberrant metabolites.

When identified early, several inborn errors of metabolism lend themselves to dietotherapy as a means of reversing the disease process and, hopefully, spare the effects of developmental retardation. Two classic examples are phenylketonuria and galactosemia, both inborn errors of metabolism, both associated with a progressively deteriorating clinical course and, if unrecognized, mental retardation is the end result. Reduction of exogenous phenylalanine in PKU and milk sugar in galactosemia has resulted in normal growth and development for affected individuals when instituted at an early age. Other disorders such as arginino-succinic aciduria, hypervalinemia and maple syrup urine disease have seen varying degrees of success in dietotherapy. A great many inborn errors as yet have no treatment proven effective.

Although relatively rare disorders, inborn errors of metabolism are potentially preventable diseases. Their association with mental retardation makes them an even more desirable target of preventive medicine. It behooves us as health professionals to continue and even augment proven effective screening tests for inherited metabolic disorders. Nurses are especially in an advantageous position to monitor biochemical and developmental screening in well baby clinics or mobile county health units.

It is of prime importance for all health professionals dealing with children to seek out the latest information related to early intervention and prevention of mental retardation. Recognition, early diagnosis and proper management for inborn errors of metabolism are important areas in which the health team should collaborate in reducing the incidence of developmental disabilities of childhood.

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Community Nutrition

How to Recognize and Improve the Nutrition of Preschool Children From Poverty Families

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Surveys of preschool children from impoverished families (Zee, 1970) have demonstrated that large numbers of children are undernourished but their condition goes undetected.

The primary physician, nurse or other health worker will only rarely meet a blatantly malnourished child in their practice. However, closer examination of a preschool population may reveal an over-representation of small children with thin extremities, frequent skin and respiratory infections, who may be less mischievous than ordinary children. Local vital statistics will indicate the existence of prenatal undernutrition through a high mortality rate of infants and a high prematurity birth rate or still-birth rate. It must be noted that 40 percent of these "so-called" premature babies are not premature, but are small despite a normal length of gestation.

Only through more sophisticated methods can the large number of infants with stunted growth, anemia, low plasma iron and vitamin deficiencies be detected. The occasional child with obvious textbook symptoms of malnutrition probably represents one of the many unrecognized poorly nourished children, who happened to meet with a superimposed social mishap, such as a father who lost his job or an alcoholic mother, and in the course of events developed acute symptoms of classical malnutrition.

The sporadic detection of such a malnourished child in a community leads to false conclusions regarding the real nutritional status of the child population. It is believed that such nutritional problems are rare, that they can easily be alleviated as the child will probably improve on a hospital diet alone, and that the essential problem is a social one. The fact is, however, that undernutrition of a lesser degree is very common in the community. Large amounts of food will be needed to correct the situation as well as an organization to distribute the food, with the assistance of a social agency being of secondary importance.

The nutritional characteristics of a poverty population can be illustrated by a study conducted in a South Memphis community of approximately 4,000 preschool black children, who participated for 3 years in a USDA* supplementary food program. Some of the families received additional benefits from food stamps, day care centers and an infant formula program. We determined the effect of these programs on a random sample of 250 children who were examined in 1972 for their height, weight, head circumference, hemoglobin, serum iron and vitamin levels of A and C. Subsequently, the data were compared to a similar survey, which we had conducted 3 years before in the community.

The results indicated significant improvement in height and weight. In 1969, the height and weight of 50 percent of the children were below the 25th percentile of normal growth charts. By 1972, only 29 percent of the heights and 39 percent of the weights were below this norm. The improvement was statistically significant. The incidence of anemia decreased from 25 percent of the children in 1969 to approximately 11 percent in 1972. However, a more elaborate way of determining iron nutrition, such as measuring the serum iron content of the blood and the saturation of the serum protein with iron, showed that approximately 53 percent of the children under 2 years were still deficient. Children who are deficient in iron but have normal hemoglobins are still at risk for anemia, especially when they have infections or when their iron needs increase as they become teenagers. Plasma vitamin A concentrations were low in only one-fourth of the population as compared to half the population in 1969.

Even more dramatic improvements were seen in the babies who were provided with a commercial infant formula that had been enriched with iron and all necessary vitamins. Not only was the incidence of anemia considerably lower than those who had received a formula not enriched with iron or vitamins, but the children did grow better in height, weight and head circumference. We have demonstrated similar improvements in a city-wide infant formula program car-

*United States Department of Agriculture

ried out by the City of Memphis and the Public Health Department.

We conclude that stunted growth, anemia and low levels of vitamins occur frequently in children from impoverished families. Federal assistance food programs and infant formula programs are effective ways to measure the growth, the nutrition and the health of these children. They are effective preventive public health measures.

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Dietary Treatment of Phenylketonuria

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The untoward effects of PKU can be prevented if dietary treatment is started early. However, the diagnosis *must* be confirmed before starting treatment. To review, confirmatory evidences are:

1. elevated serum phenylalanine ↑ 20.0 mg% or above,
2. normal serum tyrosine 1-3 mg%,
3. elevated urine phenylalanine,
4. elevated o-0H-phenylacetic acid in urine ↑ 4 mg/gm creatinine,
5. low tolerance for dietary phenylalanine. (1)

Treatment Fundamentals

Objectives of treatment are:

1. Reduce concentration of phenylalanine in blood by reducing phenylalanine intake.
2. Adjust phenylalanine intake to maintain phenylalanine levels within a range which assures sufficient phenylalanine for growth without permitting accumulation of phenylalanine or its normal metabolites. (2)

Though the disorder of PKU was described by Folling in 1934, the treatment utilizing a diet low in phenylalanine was not attempted until 1952 by Bickel from England. A diet restricted in phenylalanine, one of the essential amino acids, presents problems:

1. Most natural proteins contain 4-6% phenylalanine . . . therefore, regular foods cannot be used.
2. Synthetic formula is necessary.
3. Formulas available are deficient in or devoid of phenylalanine; therefore, a combination of formula and regular foods is necessary.
4. Since essential amino acids must be ingested in a proper balance for maximum utilization and growth, the diet must maintain a balance in phenylalanine from formula and from regular foods.
5. Amino acid requirements vary from individual to individual; therefore, each child's diet must be tailored to meet his specific needs. (2)

The Low Phenylalanine Diet

The total daily food intake for a phenylketonuric child is a specified combination of the following items:

1. A powdered protein substitute low in or devoid of phenylalanine such as Lofenalac*, Albumaid* or Aminogran*,
2. Regular foods in specified amounts,
3. Vitamin-mineral supplements,
4. Sufficient fluids for age,
5. Phenylalanine-free energy sources.

At the Child Development Center the protein substitute used is Lofenalac*. This product is prepared from enzymatically hydrolyzed casein from which most of the phenylalanine has been removed by charcoal adsorption. This product contains an adequate supply of all other essential nutrients except phenylalanine. Since it is purposely deficient in phenylalanine, it should not serve as the sole source of food for a child with phenylketonuria for more than 24-48 hours. The well-planned low phenylalanine diet for children of all ages includes regular foods. These foods make up the difference between the phenylalanine supplied from Lofenalac* and the amount needed to support positive nitrogen balance and growth. Exchange lists are available for the regular foods included in the diet. Regular foods provide some of the textures, colors and forms important to children as they grow and develop appropriate food habits.

*Registered Trademark

Phenylalanine Deficiency

One of the most serious problems encountered with the low phenylalanine diet is the danger of deficiency. Actual or impending deficiency will be clearly apparent if blood and urine tests are performed regularly.

There are three stages of phenylalanine deficiency:

1. First stage
   a. serum level 2 mg% or below
   b. low excretion of phenylalanine
   c. lethargy, anorexia, fever and vomiting
2. Second stage
   a. abrupt rise in serum level to 10-12 mg%

b. elevated urine phenylalanine
c. o-0H-phenylacetic acid appears in urine
d. amino acid excretion pattern changes

3. Third stage
   a. low serum and urine phenlalanine levels
   b. low levels of other amino acids
   c. feeding difficulties, general malaise, failure to thrive, protein depletion, retardation growth, bone changes, refractory anemia and sparse hair. (3)

Monitoring Methods

A team approach to management of phenylalanine deficiency has been recommended by the American Academy of Pediatrics. (1) The major function of this team is to correlate biochemical, dietary and clinical data in such a way that prompt and specific recommendations can be made to meet the patient's current needs.

The biochemically well-controlled patient should:

1. maintain serum phenylalanine levels of 3-10 mg%,
2. maintain normal urine phenylalanine levels varying from 25-150 micrograms per ml,
3. have no o-0H-phenylacetic acid in urine. (4)

If the blood and urine tests reveal findings within these limits, the child's total daily intake of phenylalanine is probably sufficient for growth and low enough to prevent accumulation of phenylalanine. Isolated infrequent biochemical determinations do not constitute adequate monitoring. In the first week of treatment, blood specimens should be checked daily; then when control range is reached, samples should be checked weekly; then every two weeks. After age 2, levels can be checked monthly. (4)

Dietary records of food intake should be kept prior to each blood test so that dietary intake and biochemical data can be compared.

In addition to biochemical and dietary information, the team also depends on the following observations for judging the patient's progress on the low phenylalanine diet:

1. Height and weight measurements to assess physical growth as well as clinical observation to assess development,
2. Psychometric assessment,
3. EEG's and neurological examinations,
4. Social assessment,
5. Speech and language evaluations.

The members of the metabolic team know that the optimal results of dietary management represent a long-term responsibility for them and the parents. As yet, it is not known how long treatment should be continued. Some workers are discontinuing treatment when the child reaches his third birthday. The PKU Collaborative Study, a research project being carried on by 18 major medical centers in the United States under funding by the Bureau of Community Health Services, has been working on this problem since 1968. They have now begun termination of the diet for selected children at age 6 years. These children will be carefully monitored off the diet, and their progress will be compared with that of a group of children kept on diet. (5) Of course, the final decision regarding continuation of diet in this study, as it should in all cases, rests with parents of the PKU child.

Pregnant Phenylketonurics Need Treatment

Intrauterine growth retardation, microcephaly, mental retardation, congenital malformations in infants and spontaneous abortions are among the detrimental effects of maternal phenulketonuria on fetal development. (6) High blood phenylalanine levels in mothers may be a cause of mental retardation in children who are able to metabolize phenylalanine in a normal manner. Since some women have elevated serum phenylalanine levels without the untoward effects of PKU, they may go undiagnosed throughout life. Because of the potential damage this could cause to the unborn child, the logical step appears to be to screen women routinely for this disorder. Dietary treatment for known women with PKU should be reinstituted during their reproductive years. (7)

Problems with Treatment

1. Satiety.
2. Menu Planning. The mother must learn to estimate how much phenylalanine her child consumes at each feeding. Although her child's diet is special, the mother should use the same relaxed feeding methods that encourage comfort and cooperation in her child. Rather than force and frustrate the child at mealtime, she must be able to confidently change menu plans so that his diet will provide the prescribed amount of phenylalanine. It is much easier and more successful to adjust the diet plan to the child than the child to the diet plan.
3. Low Cost Bread. Since wheat flour is high in protein and thus phenylalanine, a special bread product is needed for children, particularly as they grow older. Special bread mixes are available, but they are quite expensive. Special bread recipes using starch have been developed, but the products made from them are usually of poor quality. Recently low protein bread products have been developed for use with renal patients and can be adapted for children.
4. Knowledge of Growth and Development. As with any chronic disorder, a degree of anxiety permeates each household. Parents are concerned and have much difficulty handling their feelings and treating their child normally. By understanding normal growth and developmental milestones, parents of treated phenylketonurics are

reassured as their children meet these marks at appropriate ages. Further they are reassured by the team at each visit to the clinic and actually look forward to the blood tests as an assurance that they are managing the diet correctly.

5. Food Preparation. Mixing Lofenalac* can be a problem. A blender or mixer in this case is almost a necessity. Other food preparation problems include formula dilution, inclusion of Lofenalac* in foods and preparation of special breads. It is important that parents let the child's plate contain some of the same foods the family eats. This may pose both planning and preparation problems.
6. Discipline. Parents may have trouble setting limits on their child which may lead to all kinds of discipline problems. The child with PKU must be taught certain principles of his diet early and must learn not to accept foods he cannot have. Discipline problems may be intensified when grandparents are not fully informed regarding the diet and indulge the child thus setting off family conflict. (8)

*Registered Trademark

Summary

The mental retardation associated with phenylketonuria can be prevented or favorably modified if a special low-phenylalanine diet is started early in life. Those concerned with child health are faced with the challenge of finding these children during early infancy. The identification of the retarded child with PKU is of importance at any age, as it also alerts the family to the possibility of this condition in a younger sibling or in future children who could be treated. It has been suggested that all children under 3 years, who are discovered to have PKU, should be given a trial diet. Some, but not all, children on diet from early infancy have continued to do well when diet was discontinued after 4-5 years of age. Since there is not enough evidence to insure that optimal development and learning will proceed normally off treatment, discontinuation of treatment must be done only after careful consideration of all factors involved and on an individual basis. It is recommended that a health team follow children with this disorder since so many aspects of care are needed.

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Behavior Modification

Approaches to Teaching Feeding and Toileting Skills to Handicapped Children

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One of the major characteristics of handicapped children, particularly the mentally retarded, is some delay in reaching developmental milestones in self-help skills. It is frequently assumed that these skills will develop to an adequate level without intervention as a result of further maturation. Often this is not the case and the person fails to attain a skill necessary for independent functioning. As a consequence of such unintentional neglect, the handicapped person is susceptible to unnecessary institutionalization and the family to unnecessary monetary and personal expenditures. By using the available behavior modification technology, most of the basic self-help skills can be attained by handicapped persons, including the profoundly retarded.

It is important that those involved as trainers or supervisors should read how self-help problems have been successfully attacked. The Journal of Applied Behavior Analysis covers a wide range of behavior problems and discusses treatment in considerable detail. Many of the journals devoted to the handicapped also report behavior modification studies in some detail.

A major problem in implementing behavior modification programs is the high initial investment of time usually required, particularly in the self-help areas. Whereas temper tantrums may be reduced or eliminated in a few days, the development of feeding and toileting skills may involve weeks of intensive effort. Once these skills have been acquired, however, the amount of time spent in dealing with them is dramatically reduced from that spent prior to behavior modification intervention. For example, a program to train a severely retarded child to eat or toilet properly may involve up to 6 hours per day for 3 weeks. This may be contrasted to some 2 hours per day before treatment and 15 minutes per day after treatment. With such results, the total time saved in the year following training would be approximately 639 hours. Thus, the extra 80 to 100 hours spent on intensive training is returned 6 or 7 fold the first year. When projecting such gains over longer periods or even the lifetime of the child, the importance of making the initial commitment of time is even more obvious, not to mention the humane and humanizing aspects of independent functioning.

The purpose of this paper is to briefly summarize some of the current approaches to training handicapped children in the areas of feeding and toileting. Many of the techniques used in these areas may be adapted to other self-help skills.

Feeding Training

In general, feeding training requires the development of skills in three areas: (1) reducing inappropriate behaviors such as spilling food, eating with fingers, stealing food, eating inappropriate items, etc., (2) developing feeding skills such as holding the spoon, loading the spoon and taking it to the mouth, cutting food, using appropriate utensils, etc., and (3) maintaining the previously acquired behaviors on reduced schedules of monitoring.

It is always difficult to specify in advance the specific behaviors or patterns of behavior that may require modification in a child. Therefore, objective data should be recorded prior to planning any program. This information should specify the number of bites which are appropriately taken during a set mealtime period, the number of prompts which are necessary to raise performance to a given level, the amount of food spilled, and other details of eating performance. Such observations are then used to plan a program to correct deficiencies and later to evaluate the success of that program.

Those subjects with good eating skills, but with disruptive or messy habits, may be simply managed with a brief timeout contingency consistently applied (Barton, Guess, Garcia, and Baer, 1970). Another technique which is useful with slow, finicky, or picky eaters is a "mini-serving" approach (Stimbert, 1973). The child is given a small plate of food containing only a few bites of both preferred and nonpreferred foods. The child is given 10 minutes to complete this serving, if the plate is not empty it

is removed. If the food is eaten before 10 minutes have elapsed, another identical serving is presented and the procedure is repeated. Typically, three miniservings are allowed per session; although, the number of bites per serving and number of servings can be varied to suit individuals. Meals are always terminated if disruptive behavior occurs. This technique must be applied to all meals and snacks between meals should be eliminated. This approach has two benefits. It allows the child to be successful in finishing his meals and increases the probability of appropriate eating at later meals if the meal is terminated prior to satiation. It should be realized that most parents and aides are resistant to removing food from a child even though it may improve his nutritional status in the long run. Thus, home programs involving the restriction or removal of food must be closely monitored.

The most effective technique for dealing with a wide range of deficient eating skills is the "mini-meal" method (Azrin and Armstrong, 1973). This program was designed for profoundly retarded adults who had actively resisted previous training. It has been successfully used with children at the Child Development Center and is adaptable to varying degrees of trainability and manageability. In the mini-meal program, the regular meals are divided into smaller portions and served hourly throughout the day. Physical or manual guidance by the trainer is used to teach proper eating skills. As appropriate behavior is learned and the child is able to perform on his own, this guidance is gradually reduced but always reinstated when errors occur. Only one utensil is used per meal until all have been mastered individually. Misbehaviors and errors are always corrected (or overcorrected) by the subject, and the trainer is never directly involved in clean-ups. With children who are difficult to manage, two trainers should be used to assure that errors do not occur. Azrin and Armstrong (1973) report that by using the mini-meal procedure, errors were reduced from 83 percent to 6 percent for all residents within 12 days. Normal employees averaged about 9 percent errors on their meals. After training, the subjects of this study could be supervised in the dining room by only one or two attendants.

Toilet Training

Similar to other self-help skills, normal toileting requires numerous prerequisite behaviors or subskills ranging from control of the eliminative musculature to pulling pants down and up. Some children will have few, if any, of the components in the chain of behavior known as toileting, while others may have only a single minor difficulty which is disrupting the chain. Thus, a behavior analysis based upon observed and recorded responding by the child is essential prior to actual toilet training. Parents are asked to keep a daily record of the child's eliminative habits. Usually they are asked to record for approximately 1 week the behavior of the child without parental interference. The second baseline is then taken with the child being guided to the bathroom on an hourly schedule. On the elimination record, the parent merely checks the appropriate category which describes the child's actual behavior. For example, "failure" refers to the child not eliminating when taken to the bathroom and "accident" refers to soiled clothing at that time. "Success" indicates that the child actually eliminates in the toilet. Based upon information from these two baselines, a program of systematic training is instituted. If early components in the chain are weak or absent (child refuses to go in bathroom), these are reinforced separately as are late components (child cannot pull pants up). Small rewards such as sips of cold drinks or small items are given for participation even if the child is guided by the parent. Larger rewards such as a whole bag of candy are given for successes.

In general, the child is required to sit on the toilet for 3 to 5 minutes. A portable kitchen timer, which rings a bell at the end of this time, is helpful in maintaining this behavior, since it may signal a reward as well as the opportunity to get down. Individual children may require extensive training just to teach them to sit quietly. For some children, it may be necessary to reward them for merely sitting with their pants up before it is possible to get them to sit with their pants down. Individual differences dictate the amount of time that must be spent in developing the various subskills of toileting.

When the child can be guided without resistance through the entire sequence, there is some chance that "successes" may occur. If, however, none are recorded within 4 weeks, a more frequent 30-minute schedule may be used. If no successes have occurred or performance has not improved by the end of 8 weeks, the time required for the child to stay in the bathroom may be increased to 10 or 15 minutes. Also the child may be required to clean up his own soiled clothing and any mess which his accidents cause. If these increasing demands do not lead to steady improvement within 3 to 6 months, the rapid toilet training method (Azrin and Foxx, 1971) may be necessary. It will be highly effective for the majority of children, but should probably be used as a last resort because of the requirement for large amounts of parental or staff time.

Summary and Conclusions

This paper has presented an overview of some effective techniques in teaching feeding and toileting skills to handicapped children. Research to date indicates that children, who previously could not be taught with behavior modification techniques that were usually effective, can acquire important self-help skills with intensive programs such as mini-meal or rapid toilet training systems. The role of the profes-

sional in teaching the handicapped is to become thoroughly familiar with the most effective techniques that have been developed and to determine which ones might be effective with the least disruption of the home or ongoing programs. By starting with the least demanding program, there is, of course, the possibility of failure, but there is also the possibility of marked improvement with minimal effort. At present there is no way to determine just what it will take to correct a behavior problem, but it is encouraging to know that there is a way.

Developmental Screening

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The community health nurse is in a unique position in having the first and often the most consistent contact with families, as she provides health care to the infant, preschool and schoolage child. The extension of this health care to include some method of developmental screening of infants and children and recording of results is encouraged. For years nurses have worked with mothers and children and have made valuable assessments. Many times astute observations have been stored only in the nurse's memory or recorded in some meaningless way; thus, early identification of developmental lags has been unrecognized. The management of children with developmental problems, including mental retardation, is more effective when begun early in life. Systematic developmental assessment of infants, toddlers, and preschoolers is one approach to detecting developmental delay, which allows an early referral to be made so appropriate therapy can be initiated.

A thorough understanding of normal patterns of growth and development and expected behaviors of infants and young children is essential before attempting early identification of delays and deviations. (1) It is assumed that nurses gain this understanding as part of their basic nursing education, but if a long period of time has elapsed since your basic nursing or if this was a weak area in your program, it is strongly advised that you spend time in reviewing this area.

Parents and sometimes children tend to be anxious during developmental screening. Every effort should be made by the nurse to be supportive during the screening and to interpret the results to parents in a positive way. Adhering to the general test instructions and following the steps outlined for administration will save time and avoid pitfalls.

Several devices for developmental screening are now available for use in daily child health practice. Five of these devices will be discussed: the Washington Guide to Promoting Development in the Young Child; the Denver Developmental Screening Test; the Developmental Screening Inventory, which includes a wheel device entitled "Guide to Normal Milestones of Development;" the Developmental Profile; and the Rapid Developmental Screening Check List.

The Washington Guide to Promoting Development in the Young Child was specifically designed to assist the nurse in observing, assessing, casefinding, and planning developmental intervention for the child from birth to 5 years. It is presented in its entirety in the publication, "Teaching the Mentally Retarded Child—A Family Care Approach," by Kathryn E. Barnard and Marcene L. Powell. Organized sequentially, the developmental items are arranged progressively from simple to more complex tasks that are expected of a child at different age periods. This allows the nurse to determine where the child is functioning developmentally, to provide parental counseling, to offer anticipatory guidance and to give suggestions in promoting the child's development. Appropriate referrals can be made on the basis of the data obtained. (2)

The Denver Developmental Screening Test was devised to provide a simple method of assessing the development of infants and preschool children from birth to 6 years. (3) This screening tool enables the examiner to note whether the development of a child is within the normal range. It is not an intelligence test and does not enable one to make a diagnosis. The developers stress that it is intended only to alert the examiner to the presence of a developmental problem that needs further study. (4)

The Developmental Screening Inventory, developed by Knoblock and Pasamanick, screens children from 1 month to 18 months. (5) It is of value for serial observations in well baby supervision and for diagnostic problems. A large number of questions are included for specificity. Nurses should receive careful instruction in the use of this device before it becomes part of their nursing activity.

The Guide to Normal Milestones of Development, a wheel device designed to remind the nurse of basic steps in development, can be used as a quick reference for developmental

milestones and to more precisely describe a child's physical limitations. This device allows both the reflexes and the milestones to be assessed at the same time.

The Developmental Profile, published in 1972, is described by the authors as an inventory of skills, which has been designed to assess a child's development from birth to preadolescence. (6) The inventory provides a reliable screening of five areas and a developmental age level for each.

This Profile does not stress direct observation of the child; items may be passed or failed on the basis of an interview with the parent or person knowledgeable about the child. Assessment of developmental status by the nurse is more beneficial in the matter of reporting and describing the performance through direct observation.

The Profile has been utilized extensively by nurses for the schoolage population. Until the Profile was published, nurses met with some difficulty in developmental screening of schoolage children by any standardized measure. This tool is a welcome addition to the repertoire of screening devices—particularly because it includes the schoolage child.

The Rapid Developmental Screening Check List is a compilation of developmental accomplishments matched against the age of the child. It was developed by the Committee on Children with Handicaps, American Academy of Pediatrics, New York, Chapter 3, District II. Substantial deviation from the expected age values makes further developmental evaluation mandatory.

The one-page Rapid Developmental Screening Check List can be used, filed away in the child's health record, retrieved, and used over and over again. Early recognition of developmental lags will lead to early diagnosis and treatment, the results of which may make a big difference in the lives of these children.

Earlier casefinding, earlier intervention, and more systematic referral are some of the positive outcomes that can be expected from the implementation of systematic developmental screening of children in nursing practice.

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Tests

The tests may be obtained from:

Denver Developmental Screening Test
LADOCA Project and Publishing Foundation, Inc.
East 51st Avenue & Lincoln Street
Denver, Colorado 80216

A Developmental Approach to Casefinding
DHEW Publication No. (HSA) 75-5403
For sale by the Superintendent of Documents,
U.S. Government Printing Office
Washington, D.C. 20402 Price: $2.50

Teaching the Mentally Retarded Child: A Family Care Approach
The C. V. Mosby Company
11836 Westline Industrial Drive
St. Louis, Missouri 63141
Paperback price: $4.50

Psychological Development Publications
7150 Lakeside Drive
Indianapolis, Indiana 46278

Rapid Developmental Screening Check List
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